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MALIGNANT ADENOMA OF THE LUNG

CARCINOMA-LIKE TUMORS WITH LONG CLINICAL COURSE

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DURING the past decade the role of carcinoma of the lung has changed from a subject of interest chiefly to pathologists, to a problem of major importance for clinicians. Since 1933 an ever-increasing number of patients have been treated successfully by surgical extirpation of the lung and tumor-bearing tissue. Prior to this period the mortality of the tumor was 100 per cent[1,2,3] and a correct diagnosis was frequently lacking until post-mortem examination.

With the development of successful surgical measures for this tumor clinical interest became widespread. Thus it was not appreciated until recent years that the incidence of carcinoma of the lung is about 10 per cent of all malignant tumors or second only to carcinoma of the stomach.[4] It has been estimated that approximately 15,000 deaths occur annually in the United States due to this tumor. Successful surgical therapy has been employed for an insufficient time to allow for future predictions. However, it is probably safe to say that at the present time the outlook for carcinoma of the lung is better than that for carcinoma of the stomach.

This report deals with a particular type of tumor of the lung over which much controversy has continued. Two widely divergent opinions as to their proper management are prevalent at the present time. By one group these tumors are considered benign and are treated as such by bronchoscopic removal.[5,6] A second group classifies them as malignant and advises treatment by total pneumonectomy.[7]

The marked variability in the clinical course of malignant tumors of the lung in general has helped to confuse an attempt at proper classification and correct management.

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This is especially true with the group of cases under discussion. Clinically they behave like benign tumors for months or years, giving rise to symptoms only by obstruction of the air passages. Ultimately they show definite evidence of malignancy by involvement of adjacent structures by direct extension and by distal metastases although few or no mitotic figures are demonstrable.

REPORT OF CASES

CASE 1.—W. W. (No. 226258), a white female, 33 years of age, entered the hospital on Aug. 18, 1939, complaining of a persistent cough with repeated "colds" for five years, and repeated severe attacks of hemoptysis for four months. The cough had been somewhat more pronounced during the winter months and often her sputum had a brownish tinge. On April 29, 1939, the patient had a severe hemoptysis. She was in a hospital for one month with a diagnosis of pneumonia of the right lower lobe. Five days after discharge, she felt ill and her temperature was 101°. X-rays of the chest were made and her condition diagnosed as "bronchiectasis." After three weeks in a sanatorium she was "much improved." The next severe hemorrhage was on July 31 when she "coughed up a teacup full of blood." A bronchoscopic examination with biopsy of a tumor mass in the right lower lobe bronchus was made but a definite diagnosis was impossible. Her hemoptysis gradually subsided until one week before admission when it recurred in severe form and continued until admission to the hospital. The bloody sputum had recently become foul. The patient had lost fifteen pounds in the past two years and had become weaker and developed some dyspnea with the repeated hemoptyses and attacks of fever. She stated that she had had an attack of pneumonia two years before admission.

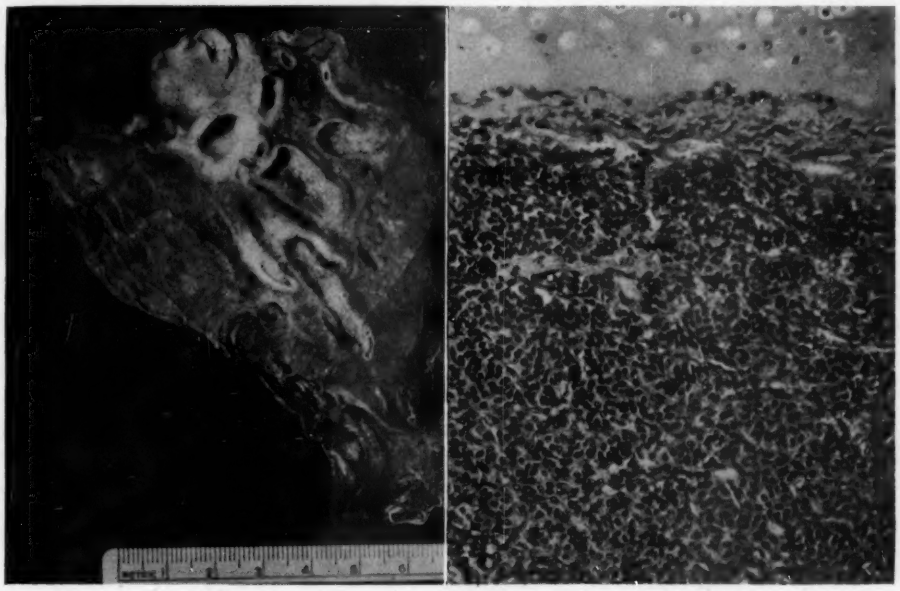
Physical examination revealed an anemic, chronically ill appearing white female who raised sputum tinged with old blood on frequent coughing. Her temperature and pulse were normal. The abnormal physical findings were limited to the chest. Expansion of the right side was somewhat diminished. There was an area of dullness over the region of the right lower lobe. The breath sounds over this area were decreased. Tactile fremitus was unchanged. There were no râles. The blood pressure was 105/70.

Laboratory Examination.—The blood revealed a hemoglobin of 47 per cent; R.B.C., 3.30; and W.B.C., 7,550. The sputum was grossly bloody. On staining it presented no evidence of tubercle bacilli and on culture revealed *Streptococcus haemolyticus, Str. viridans, Staphylococcus aureus* and pneumococci. The Wassermann and Kahn tests were normal. An x-ray of the chest revealed an ill-defined opacity in the right lower lung field. When this was repeated following the introduction of iodized oil, an obstruction of the right lower lobe bronchus was demonstrated. Bronchoscopy revealed a tumor in the right lower lobe bronchus which bled freely when a piece was removed for microscopic examination. Clinical diagnosis: bronchogenic tumor of right lower lobe.

The patient was given a blood transfusion in preparation for operation. Because of the positive throat culture of hemolytic streptococcus, she was given a course of sulfanilamide, however, without altering the culture. Because her condition was not emergent, she was allowed to return home, hoping that the streptococcal infection would subside. She was readmitted two months later in approximately the same condition and was found to have a persistent *Str. haemolyticus* infection of the respiratory tract. After hospitalization for ten days a right lower lobectomy was performed. Her convalescence was entirely uneventful, no em-

pyema or bronchial fistula complicating the operation. The patient gained quite rapidly in weight and strength and her symptoms were entirely alleviated. She has remained well up to the present time.

The Tumor and the Right Lower Lobe.—The surgically excised right lower lobe contained a tumor mass which was about 2 cm. in diameter (Fig. 1*A*). It was located at the junction of a branch with the main bronchus, into which it also projected. It filled and dilated the bronchus in which it arose and to whose wall it was attached by a broad base. On section the tumor was firm and white. The remainder of this lobe showed bronchiectasis, total atelectasis, and fibrous pleural adhesions. It was markedly shrunken, solid and contained little air. Purulent material filled the markedly dilated bronchi.



A. *B.*

Fig. 1.—Case 1. W. W. *A.* Photograph of the excised lung showing the intrabronchial tumor, with bronchiectasis and atelectasis distal to this point of obstruction. *B.* Photomicrograph (×165) showing the histology of the tumor and its infiltration into bronchial cartilage. Many areas, unlike this, were distinctly papillary or alveolar. Connective tissue stains reveal more stroma in this region than would be suspected from this illustration.

Microscopically the tumor was composed of uniform small polyhedral cells with hyperchromatic, round nuclei and a scanty amount of acidophilic cytoplasm. Mitotic figures were not seen. The cells were arranged on a fine fibrous stroma which had a reticulated pattern, thus producing an alveolar appearance of the epithelial cells. This tumor infiltrated its bronchus at the point of attachment, penetrating into the bronchial cartilage. (Fig. 1*B*.) The free surface of the tumor was capped by a layer of fibrous connective tissue, and this was covered, where not ulcerated, by stratified squamous epithelium. The deep portion of the tumor was separated from lung parenchyma by a less perfect layer of connective tissue.

Case 2.—L. M. (No. 178341), a white male, 37 years of age, was admitted to the hospital on July 9, 1937, complaining of a chronic cough for three years, loss of voice for three weeks and a continuous "run-down" feeling for the last three months. The patient enjoyed perfect health until four years before admission, when he began to have upper respiratory infections. Following this he developed a nonproductive cough which came on in attacks four to six times a year, each lasting

from two to three weeks. During these attacks he would lose weight and develop a fever, regaining the weight between the attacks. On one occasion the temperature was taken and found to be 104°. During the last year, he gradually began raising sputum, somewhat thick and yellow in character. To his knowledge this had never been foul. His last attack began three weeks before admission and sputum raised was found to be somewhat blood stained. Also, with this last attack, his voice became hoarse. Due to the intensity of his cough, vomiting was present during the last attack. There had been no dyspnea nor chest pain, except on one occasion two years ago and this was only temporary.

Physical examination revealed a well-developed and well-nourished white male who exhibited a frequent nonproductive cough but who did not appear acutely ill. The abnormal findings were limited to the chest and these were not remarkable. Tactile fremitus was increased over the right apical region and was decreased over the left base. The percussion note was somewhat dull at the right apex and markedly dull over the entire left base. The breath sounds here were very much diminished or completely absent. A few, scattered crepitant râles were heard over the lower portion of the left base. The cardiac borders were within normal limits. The blood pressure measured 110/70. There was no clubbing of the finger tips.

Laboratory Examination.—The blood revealed hemoglobin of 90 per cent; R.B.C., 5.18; and W.B.C., 9,500. The urine was normal as were the Wassermann and Kahn tests. The sputum showed no evidence of tubercle bacilli. X-rays of the chest revealed an ill-defined opacity involving the lower one-half or two-thirds of the left lung field. It appeared to involve the left lower lobe but did not obliterate the costophrenic angle. The x-ray diagnosis was pneumonia or pulmonary abscesses in the left lower lobe, but it was impossible to rule out atelectasis due to tumor of the left lower lobe bronchus. Bronchoscopic examination revealed a tumor located in the left lower lobe bronchus. This was quite friable and bled freely when biopsied for microscopic examination. It was diagnosed as a basal-cell carcinoma.

Since there was no evidence of metastases or marked local extension a pneumonectomy was advised. On Sept. 8, 1937, the left pleural space was explored and the entire left lower lobe found to be extremely adherent to the chest wall. On mobilizing the left lower lobe, a considerable degree of shock was produced and it was deemed advisable to divide the operation into two stages, according to the Rienhoff[20] technique. The left pulmonary artery was isolated and divided between ligatures and the wound was closed with closed drainage of the pleural space. The patient had a stormy postoperative course and developed a *Str. haemolyticus* empyema and a fulminating infection of the chest wall. Supportive measures, such as blood transfusion, intravenous fluids, and multiple thoracenteses maintained the patient in a fairly good condition for the following ten days, after which he became worse and died fourteen days following the operation of generalized sepsis and a fulminating infection of the chest wall.

The Tumor and Lung.—(Autopsy No. 4215; Prosector, Dr. Walter A. Stryker.) An egg-shaped tumor, 22 by 14 by 10 mm., occluded one of the secondary bronchi near its origin, in the left lower lobe. This tumor was attached at one point by a broad base to the bronchial wall; at other points it was free. It enlarged its own bronchus and by pressure it seemed to have occluded neighboring bronchi. On section the tumor was solid white, and it appeared to have infiltrated the bronchial wall at its base.

The lung lobe containing the tumor was reduced in size. The lung distal to the tumor was flabby and atelectatic, and the bronchi distal to the tumor showed a remarkable dilatation, being up to 1 cm. in diameter. They contained yellow pus. (Fig. 2*A*).

Microscopic examination disclosed that the tumor was composed of fairly uniform small cuboidal to low columnar epithelial cells arranged diffusely or abutting on small cores of connective tissue stroma bearing small blood vessels. The cells were fairly uniform, appearing round to oval, and had hyperchromatic nuclei in which the chromatin pattern was diffuse except for a little clumping. Mitotic figures were not seen. The cytoplasm was scanty, clear, and slightly eosinophilic. The arrangement of the cells about numerous small connective tissue strands, from which the cells tended to shrink, gave the tumor, when first seen superficially, a pseudoadenomatous appearance, whereas it was truly an infinitely complex, solid, papillary structure. There was no evidence of secretion by the cells and there were no true gland lumina. Degenerative changes were absent. (Figs. 2*B* and 2*C*.)

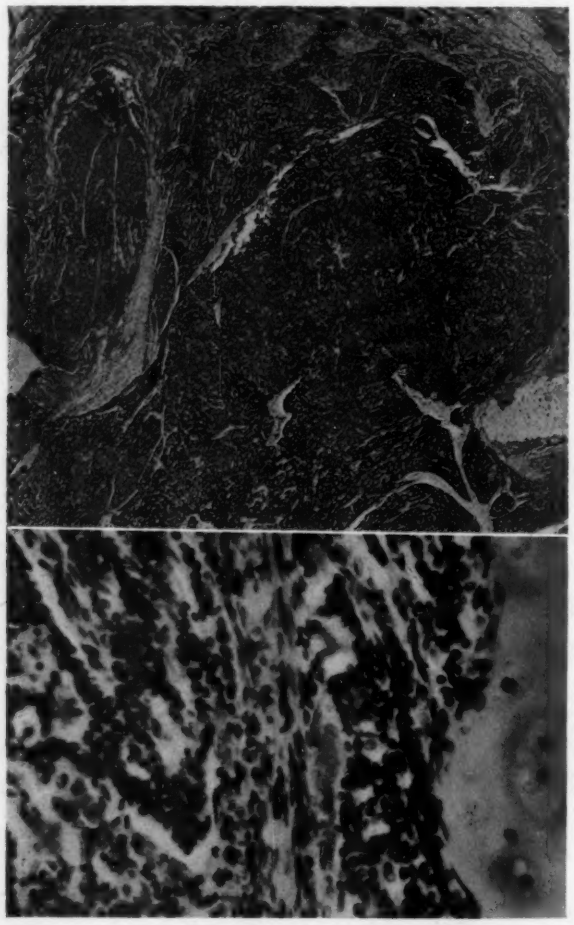
Fig. 2*A*.—Case 2. L. M. Photograph showing the polypoid intrabronchial tumor in the lower lobe with bronchiectasis and atelectasis distal to the tumor.

This solid tumor, then, filled the bronchus, which it dilated. The bronchial wall was fairly normal. The free surface of the tumor was composed, in most places, of a dense fibrous connective tissue. At its base the tumor infiltrated the bronchial wall. It denuded and destroyed superficial areas in the cartilage plates, and it bulged outward between cartilage plates into the peribronchial connective tissue. Bronchial lymph nodes and large blood vessels in proximity to this tumor extension were not involved.

The lung distal to the tumor showed a remarkable bronchiectasis. The lumens of the bronchi were increased in size and their mucous membrane was missing, having been replaced by a granulation tissue. The lung parenchyma in this region showed complete atelectasis. Many alveoli had a cuboidal epithelial cell

lining and there were areas of fibrosis, nodular aggregates of lymphocytes, and occasional giant cells, all associated with the chronic pneumonitis.

There were no gross or microscopic tumor metastases.



B.

C.

Fig. 2 *B* and *C*.—Case 2. *B*. Photomicrograph (×20) showing the intrabronchial tumor growing outward between two bronchial cartilages, which are infiltrated. A lymph node at the upper right shows no tumor metastasis. *C*. Photomicrograph (×345) showing the histology of the tumor cells and their stroma, and invasion of a bronchial cartilage on the right.

Case 3.—G. M. (No. 243282), a white female, 62 years of age, was admitted to the hospital on June 14, 1940, complaining of a productive cough and weakness since an attack of pneumonia one and one-half years before admission. The patient gave a history of having had severe attacks of pneumonia sixteen years and nine years before admission. Following the second attack of pneumonia she had a non-productive hacking cough which changed very little in character until her third attack of pneumonia one and one-half years before admission. The third attack of pneumonia was bilateral. Following this, her cough became productive without a foul odor. She did not regain full health after that time, having lost about thirty-five pounds in weight during the illness.

An x-ray film of the chest taken a year ago revealed a "shadow" in the right lower chest region which was interpreted as tuberculosis. However, the sputum was

negative for tubercle bacilli. Three months before admission a bronchoscopy was performed. A tumor found, located in the right lower lobe bronchus, was said to be a cancer. There was no history of hemoptysis or dyspnea. She had had a vague pain in the right chest for about a month and for the past six or seven months there was a history of vomiting on going to bed when attempting to lie on the right side. The remainder of the history was irrelevant.

Physical examination revealed a well-developed, fairly thin white female who did not appear acutely ill. Temperature 98.6°; pulse, 85. The abnormal findings were chiefly limited to the chest. Expansion was equal and normal. The patient coughed occasionally and this was slightly productive. Râles were present on the right side in the anterior axillary line over the lower lobe after coughing. Breath sounds and tactile fremitus were somewhat diminished over this area. There was just a suggestion of clubbing of the finger tips.

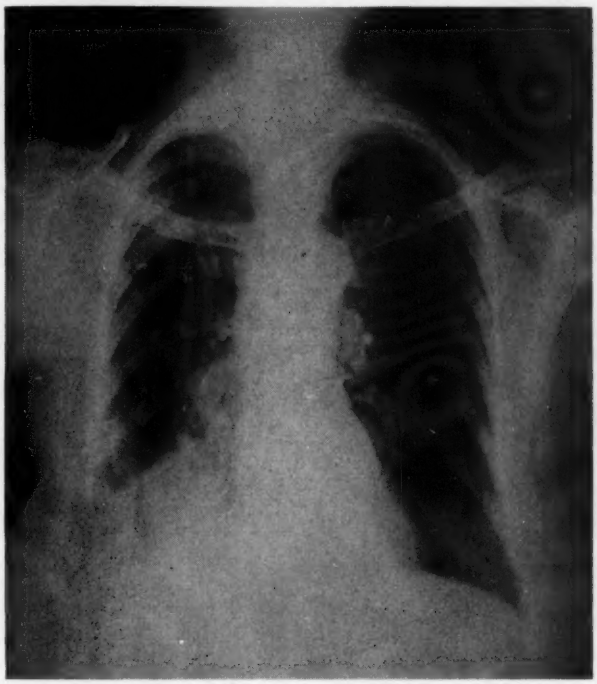


Fig. 3*A*.—Case 3. G. M. X-ray of chest on admission showing an opacity in the lower right lung field made by the atelectatic and infected right lower lung lobe.

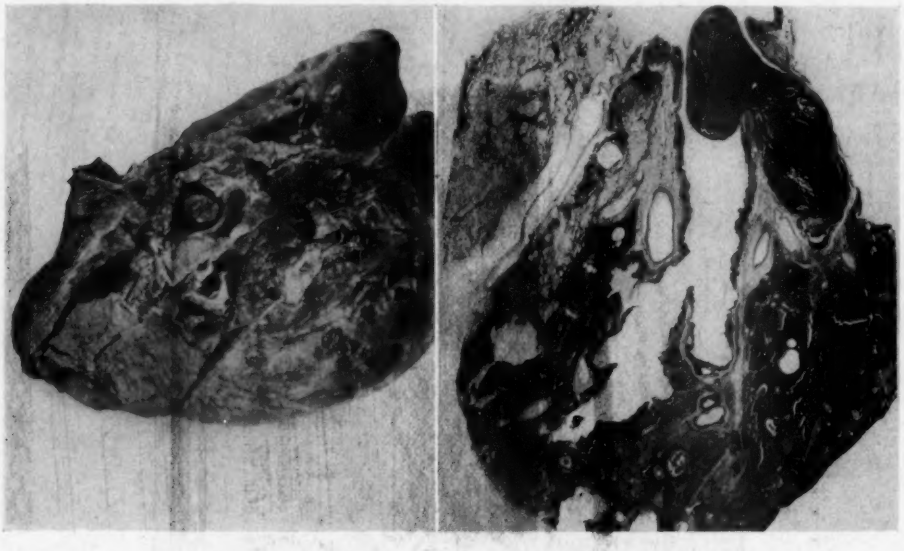
Laboratory Findings.—The blood showed a hemoglobin of 87 per cent; R.B.C., 3.64; and W.B.C., 12,350. The Wassermann and Kahn tests were normal, as was also the urinalysis. An x-ray of the chest revealed a pyramidal-shaped opaque area occupying the right posterior costophrenic angle (Fig. 3*A*). The remainder of the lung fields were relatively normal. Diagnosis: atelectasis and pneumonitis of the right lower lobe due to bronchial obstruction, probably by tumor. The bronchoscopic examination revealed a tumor in the right lower lobe bronchus. It was a red, smooth, and rounded mass and on biopsy showed carcinoma of the bronchus. The patient was prepared for an operation by transfusion, and a right lower lobectomy by the dissection technique was performed.

The patient made an uneventful convalescence for the first ten days, the temperature returning to normal. As she was ready to be allowed out of bed, massive

infarction of the right middle lobe developed. She gradually developed signs of congestion and pneumonia with cardiac failure, and died twenty-six days after operation.

Post-mortem examination revealed pulmonary embolism with massive hemorrhagic infarction of the right middle lobe, terminal pneumonia, and a small encapsulated empyema.

The Tumor and Right Lower Lobe.—(Autopsy No. 5087; Prosector, Dr. Howard C. Hopps.) The surgical specimen of excised right lower lobe showed a tumor 3.5 by 2.0 by 1.5 cm. located in the primary and a secondary bronchus of the right lower lobe, to whose wall it was attached. It filled and dilated the bronchi in which it was located. The tumor on section was hard and white. Half of the lobe distal to the tumor showed bronchiectasis and the other half showed atelectasis. (Figs. 3*B* and 3*C*.) The lung lobe was heavy and practically airless. When cut across purulent material escaped from the bronchiectatic portion.



B. *C.*

Fig. 3 *B* and *C*.—Case 3. *B*. Photograph of hilar surface of the excised lung showing the polypoid tumor projecting into the main bronchus. *C*. Photograph of a large microscopic section through the lung to show the tumor arising in a large bronchus, the bronchiectasis, and the atelectasis.

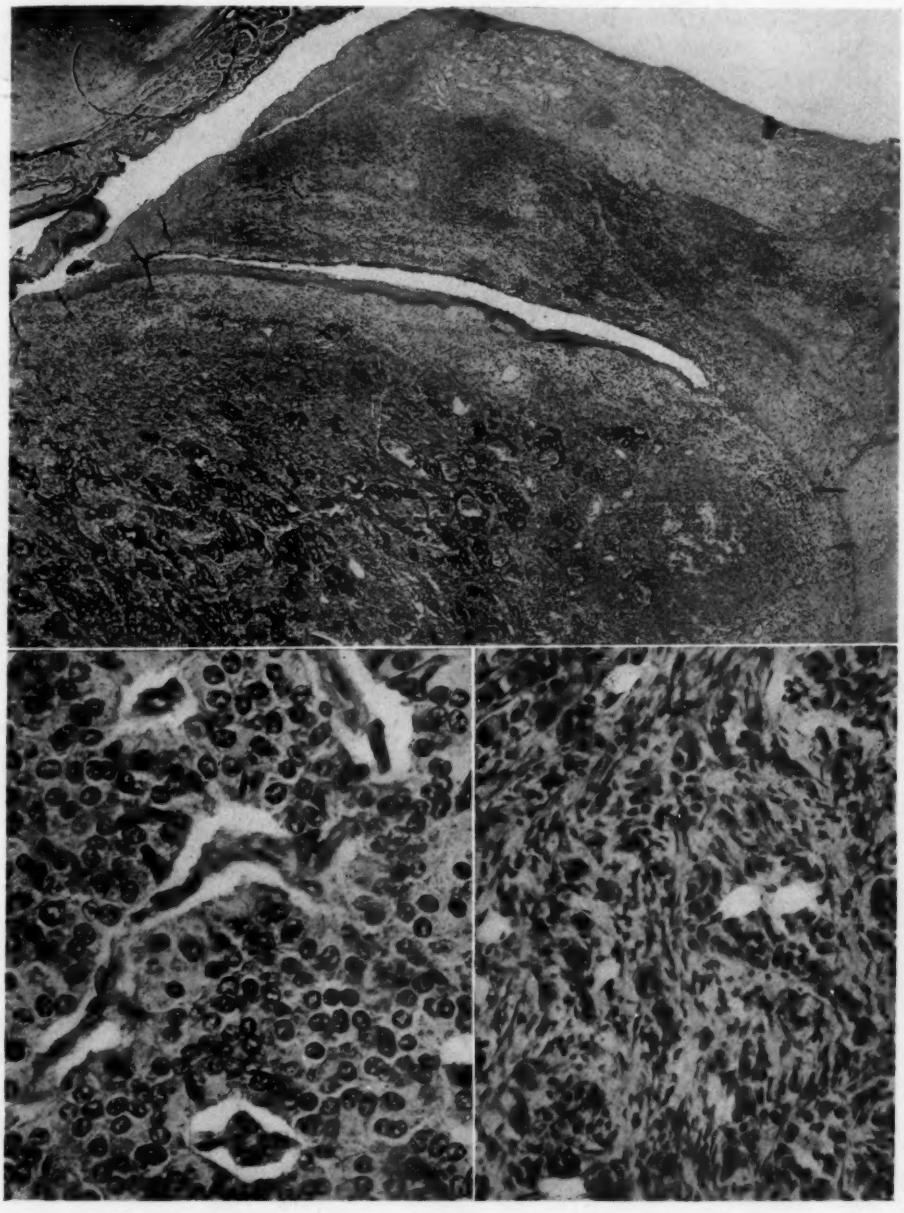
Microscopically the tumor was composed of fairly uniform polyhedral cells which grew in sheets or in several layers piled up on a uniform, vascular connective tissue framework. In some areas the cells were low columnar and they were arranged in a single layer on a distinct papillary stroma. The nuclei were uniform in size, oval, moderately hyperchromatic, and with the chromatin showing considerable clumping. Nucleoli were fairly large. Practically, there were no mitotic figures. The cytoplasm was moderately abundant, very finely granular, slightly acidophilic, and indistinct in outline. (Fig. 3*E*.)

The tumor arose from the bronchial wall. Beneath its pedicle, in bronchial lymphatic channels, nests of tumor cells were visible. At one point there was direct infiltration of tumor cells into bronchial cartilage.

The free surface of the tumor was capped by a layer of dense fibrous tissue. This in turn was covered, in the most advanced tip, by a layer of fibrin and hemorrhage. Elsewhere the tumor was covered by a stratified squamous epithelium, although the adjoining bronchial wall was lined by normal appearing pseudostratified columnar epithelium. (Fig. 3*D*.)

The bronchi distal to the point of obstruction by tumor showed a marked bronchiectasis. The lung parenchyma showed small areas of recent abscess formation. It also showed an atelectasis. The alveolar spaces contained blood which showed no degeneration.

D.



E. *F.*

Fig. 3 *D, E,* and *F.*—Case 3. *D.* Photomicrograph (×27) showing the intrabronchial tumor with its surface layer of fibrous tissue, stratified squamous epithelium, and at the upper right by a layer of fibrin infiltrated by leucocytes. *E.* Photomicrograph (×560) showing the character of the tumor cells and their stroma. *F.* Photomicrograph (×200) of vertebral body showing a tumor metastasis with more fibrous stroma and greater cell pleomorphism than in the primary bronchial tumor. This lesion was several centimeters in size and had completely replaced the marrow at this point.

In a routine section of bone taken from a lumbar vertebral body to study the condition of the bone marrow, microscopic examination disclosed a nodular, infiltrative lesion replacing the marrow cells in which the cells resembled those of the lung tumor. There was considerably more fibrous stroma than in the primary growth, and in some places the epithelial cells had died out altogether.

CASE 4.—J. D. (No. 30016), a white male, aged 47 years, was first admitted to the hospital on Nov. 19, 1930, complaining of tiredness for one year and attacks of paroxysmal coughing for one and one-half years. The patient gave a history of a severe attack of pneumonia in 1924. He went to Arizona to recuperate and remained quite well until a year before admission. However, during the years following the attack of pneumonia, he tired easily and was not up to par. For this reason his engagement in sports was given up. During the three months before admission the feeling of fatigue gradually increased and attacks of coughing became more severe. These were difficult to control. The sputum raised was fairly large in amount and quite thick and tenacious with no evidence of blood. On some occasions, on taking his own temperature, it was found to be increased by as much as one degree. The history was otherwise irrelevant.

Physical examination revealed a well-nourished and well-developed man who did not appear ill. His temperature was 99.4° and pulse 88. Examination in general was strikingly normal. His blood pressure was 130/90. His heart and lungs revealed no definite evidence of abnormality. There was no evidence of clubbing of the finger tips.

Laboratory Examination: His blood showed a hemoglobin of 85 per cent; R.B.C., 3.85; and W.B.C., 12,300. The Wassermann and Kahn tests were negative as was also the urine examination. The sputum on several examinations was negative for tubercle bacilli. An x-ray of the chest revealed a fairly sharply outlined shadow at the right hilum extending somewhat outward toward the periphery. It was considered most likely either a pulmonary neoplasm or an atypical hilum tuberculosis. The patient was observed in the hospital for a period of five weeks, at the end of which time he was quite comfortable and had had a normal temperature for over four weeks. During his stay in the hospital an investigation of the gastrointestinal tract was found to be normal. After a short time following his discharge, he returned to Arizona for a rest. His cough continued at intervals and the possibility of foreign body aspiration was considered. Bronchoscopic examination revealed the mucosa of the right primary bronchus to be intensely inflamed. There was an edematous bulge inward of the orifice of the right upper lobe bronchus. A tumor of this bronchus was suspected but microscopic sections revealed no definite mitotic figures. Because of the suspicion that the lesion was neoplastic in nature, x-ray therapy was considered advisable. From Nov. 2 to Nov. 16, 1931, he received 1,300 r. units and from January to October, 1932, he received an additional 5,131 r. units, making a total of 6,431 r. units. Following this, the patient was again seen in the Out-Patient Clinic from time to time and remained in fairly good condition until two weeks before his second admission to the hospital on Oct. 14, 1934. At that time he developed a head cold with chills and pains in the chest. An x-ray of the chest just before admission revealed no change from one taken four years previously. On the day prior to admission he developed a chill, felt flushed, became nauseated, and was brought to the hospital. His temperature was found to be 103.4°. Examination of his chest revealed little evidence of abnormality. His W.B.C. was 24,000; hemoglobin, 90 per cent; and R.B.C., 5.12. Examination of the sputum revealed a Type VIII pneumococcus. He rapidly became worse; definite signs of pneumonia developed, first on the right side and subsequently on the left. His temperature became elevated to 104.2° and the pulse 150. On the sixth day after entering the hospital he died of bilateral pneumonia.

The Tumor and Lung.—(Autopsy No. 3248; Prosector, Dr. Sion Holley.) A tumor cast filled both branches of the right upper lobe bronchus. The tumor tissue was soft, white to red, and fleshy. It dilated the bronchi, which were thin-walled, and filled two of the main bronchi which passed toward the apex of the lung, as well as some of their branches. As felt externally through the lung tissue the overall size of the tumor was roughly 5 or 6 cm. On gross examination the tumor appeared to be confined within the lumens of the dilated bronchi. Two calcified or ossified bodies were found in the tumor of one bronchus.

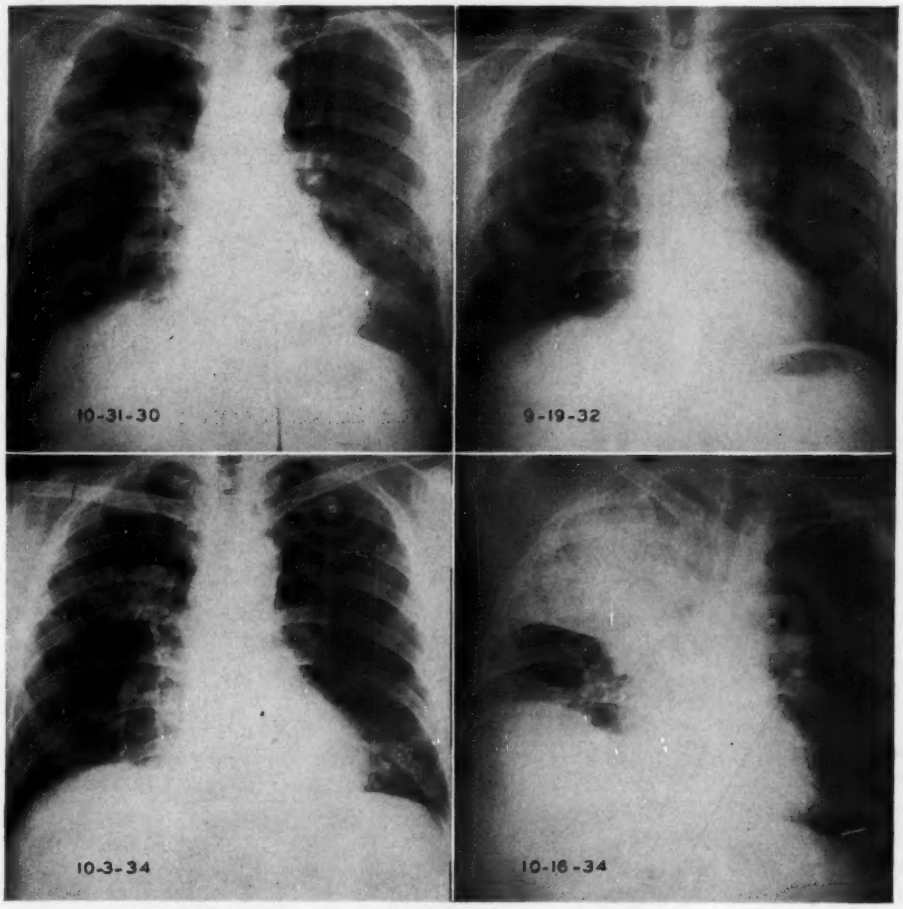
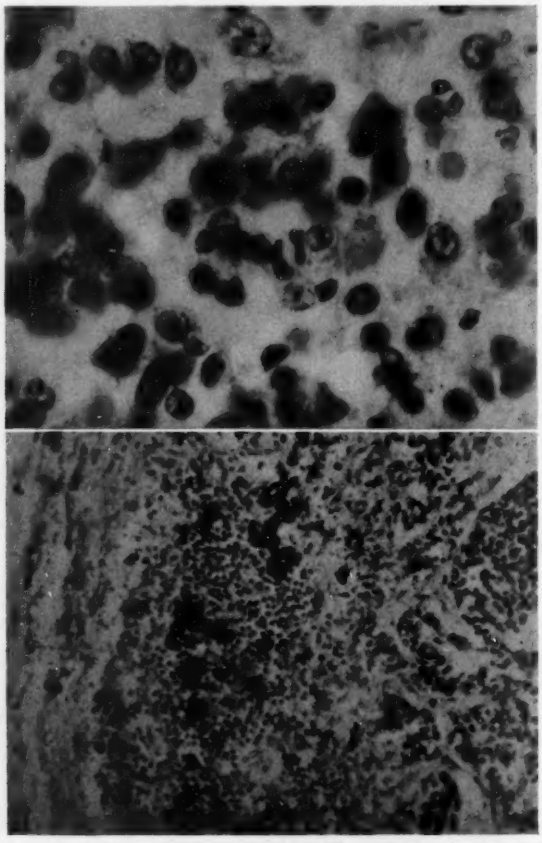


Fig. 4 *A*.—Case 4. J. D. Four x-rays of the chest over a four-year period. Note that the opacity made by the tumor in the right upper lobe remained practically unchanged during this time.

The bronchi distal to the tumor were dilated up to 12 mm. and were filled by a yellow to gray pus. The lung weighed 1,400 Gm. The upper lobe was consolidated and gray; the lower lobe was consolidated and was red-gray. Two areas of beginning suppuration were found. The middle lobe showed only a bloody edema. The surface of the lung was covered by a fibrinopurulent exudate. The left lung weighed 1,150 Gm. It showed areas of red consolidation in the apex, lingula, and upper portion of the upper lobe, a diffuse hyperemia and edema elsewhere, mucopurulent bronchitis, and fibrinopurulent pleuritis.

Bacterial cultures from each lung, heart blood, and a bronchiectatic cavity in the right upper lobe all yielded a Type VIII pneumococcus.

Microscopically the tumor was composed of small, fairly uniform, cuboidal to polyhedral epithelial cells. The nuclei were round to oval, hyperchromatic, fairly uniform in size and shape, and without mitotic figures. The cytoplasm was scanty, clear, poorly defined, and very slightly acidophilic. These cells grew in sheets but more commonly as a layer arranged on cords of connective tissue which was highly vascular but often hyalinized. (Fig. 4*B*.) The total effect was that of a semi-papillary tumor growth. This tumor permeated and filled the bronchial tree in the region of the right upper lobe as already indicated. Microscopic examination also disclosed, however, that the tumor was invading through bronchial walls in several places, and was growing in the adjacent alveoli. There was a remarkable tendency for the tumor growth to be coated by fibrous tissue, which was hyalinized, and for the bronchial walls themselves to become hyalinized even at points of tumor penetration.



B.

C.

Fig. 4 *B* and *C*.—Case 4. *B*. Photomicrograph (×1170) showing the histology of the tumor cells. *C*. Peribronchial lymph node (×330) showing from left to right periglandular fat, lymph node capsule, lymphatic tissue with anthracotic pigment, and metastatic tumor growth.

A microscopic metastasis of the tumor was discovered in one peribronchial lymph node.

Apart from the tumor the sections of the lungs disclosed bronchiectatic cavities, apparently of recent origin, filled by purulent exudate in the right upper lobe distal to the points of occlusion by tumor, and a fibrin-rich lobar pneumonia which in some areas appeared to be of recent origin and elsewhere near the point of resolution, early areas of suppuration in the lung, and a pleuritis.

CASE 5.—M. G. (No. 235601), a white female, 36 years of age, was admitted to the hospital on Feb. 5, 1940, complaining of a draining sinus in the right chest for eleven years, a second draining sinus from the anterior aspect of the right chest for four years, marked loss in weight and strength and easy fatigability for three years. The patient gave a history of a severe attack of pneumonia fifteen years before admission. This was complicated by an empyema which was drained by a physician. This continued to drain for six months after which she felt well for a period of four years. Eleven years before admission the scar of the former operation became infected and was opened by a physician. Pus had drained from this site ever since (eleven years). About four years ago, the patient noticed a lump on the front of the right chest wall, just below the clavicle. This was incised and has drained pus since that time. The patient stated that she had lost twenty-five pounds in weight up to five years before admission and an additional twenty-seven pounds since that time. She had had chills and fever on various occasions and an occasional dry cough from time to time which had been rather insignificant and never productive. There was no history of hemoptysis. The remainder of the history was irrelevant.

Physical examination revealed an extremely emaciated anemic white female who appeared very exhausted and chronically ill. Her temperature was 100° and her pulse 120. The abnormal findings were as follows: The right chest was markedly contracted, producing a considerable degree of scoliosis of the spine. A draining sinus productive of foul, yellowish-green purulent material was seen just below the right scapula. A second sinus draining similar material was located immediately beneath the right clavicle. The entire right chest was flat on percussion, tactile fremitus was markedly diminished or absent, and no breath sounds could be heard. The left lung field was relatively normal. The heart borders were within normal limits and there were no murmurs. Clubbing of the fingers was quite marked. The extremities revealed marked wasting and the patient was unable to stand because of weakness.

Laboratory Findings.—The blood hemoglobin was 40 per cent; R.B.C., 3.42; and W.B.C., 7,150. The Wassermann and Kahn tests were negative, as was also the urine examination. An x-ray of the chest revealed a lack of areation of the entire right lung with marked thickening of the pleura and a pyopneumothorax. The trachea was deviated to the right. The left lung was relatively normal. Diagnosis: chronic empyema, right.

The patient was given a blood transfusion in preparation for drainage of the empyema. A Congo red test showed only 15 per cent retention in the body. Open drainage of the empyema by rib resection (ninth and tenth) was carried out. Another blood transfusion was given and the patient made a gradual recovery, a third transfusion being given two weeks after operation. Considerable strength was regained and her temperature and pulse returned to normal. She was discharged from the hospital on the twenty-sixth day following operation, with a hemoglobin of 60 per cent; R.B.C., 4.52; and W.B.C., 7,350. The empyema cavity which measured 100 c.c. at operation had diminished to 70 c.c. at the time of discharge.

The patient was followed in the Out-Patient Clinic at weekly intervals. She gained rapidly in weight and strength and in two months had improved very remarkably. Her weight had been increased by 17 pounds; the cavity had been reduced to around 55 c.c.; the blood picture had improved to a hemoglobin of 76 per cent and R.B.C., 4.65. She was admitted on May 3, 1940, for obliteration of the remaining portion of her empyema cavity. On May 8, 1940, a first stage of a graded thoracoplasty was performed, portions of the second, third, fourth and fifth ribs being resected subperiosteally. The operation was well tolerated, little reaction being exhibited, and the temperature returned to normal on the first postoperative day. About one week later it was noticed that she exhibited a slight wheezing type of

respiration for the first time. A bronchoscopy was performed with dramatic findings. A tumor mass arising in the right main bronchial tree was seen projecting into the lower end of the trachea to such an extent that the carina was invisible and the left primary bronchus could not be seen. A biopsy removed gave the impression at first of a squamous-cell carcinoma. Edema and inflammation following the bronchoscopy caused considerable dyspnea. The bronchoscopy was repeated in an attempt to remove a sufficient amount of the tumor to obtain a clear airway to the left lung. This was again followed by marked dyspnea and during the third attempt at removal of the intratracheal portion of the tumor, the patient died, death being due to asphyxia.

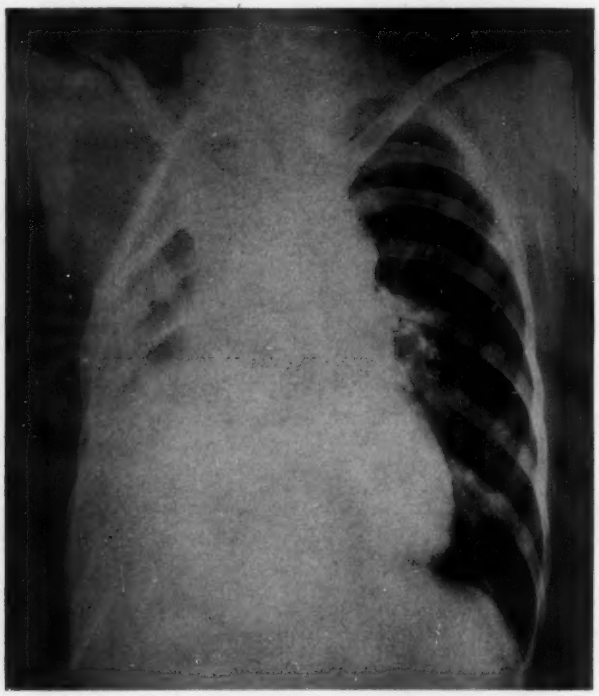


Fig. 5 *A*.—Case 5. M. G. X-ray of chest on admission. The right side is markedly shrunken and presents a chronic pyopneumothorax.

The Tumor and Lungs.—(Autopsy No. 5051; Prosector, Dr. W. M. Humphreys.) The right lung was small, airless, and solid. More than half of it was replaced by tumor tissue which centered in the greatly dilated bronchial system of the lower lobe, but which also extended into the right main bronchus, the proximal portions of the bronchi to the right upper and middle lobes, and into the trachea. The right main bronchus was filled by tumor and was dilated to twice its normal size. Proximally the tumor formed a polypoid mass which projected into the trachea for a distance of 2 cm. and partly obstructed its lumen. The proximal end of the left main bronchus wall was infiltrated by tumor. Distally the tumor formed a multilobulated mass, the different projections representing tumor growing as a cast in greatly dilated bronchi. Capping this multilobulated tumor, and filling the spaces between lobules was a layer of totally atelectatic, anthracotic lung tissue from 1 to 15 mm. thick. This in turn was covered by a greatly thickened, tough, fibrous pleura which was up to 2 cm. thick. The only pleural space which persisted consisted of two empyema cavities, one 5 cm. across and the other 6 cm., which communicated with each other and with lung abscesses, and drained to the exterior through sinus tracts, one spontaneous and the other operative.

Only near the central portion of the tumor mass was there any perceptible invasion through the bronchial wall into the lung parenchyma. The remarkable dilatation of the secondary bronchi by tumor could be followed nearly to the surface of the lung by the position of their cartilage rings, some of which were calcified or ossified. Tertiary bronchi were also enormously dilated up to 3 cm. and were filled by inspissated exudate. Some such cystic tertiary bronchi showed the blunt end of an advancing tumor polypus projecting into them. They lay near the pleural surface.

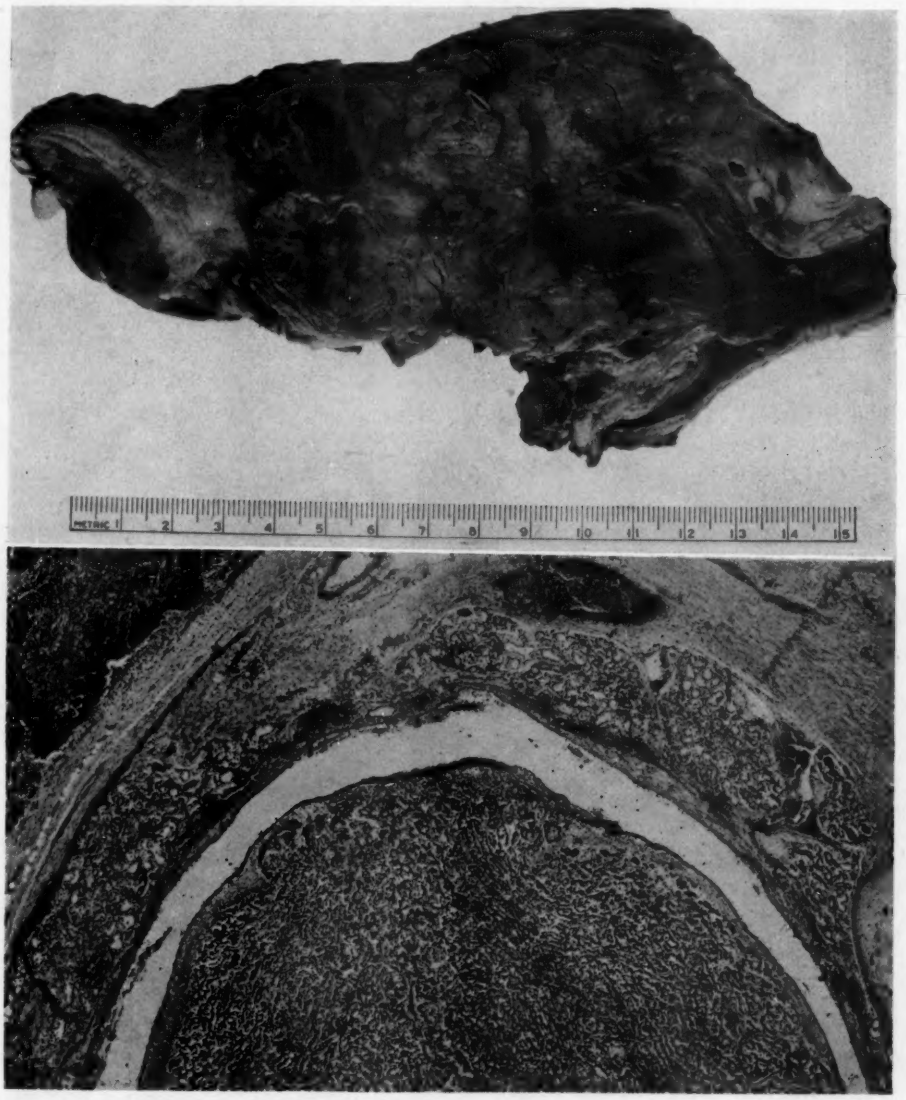


Fig. 5 *B* and *C*.—Case 5. *B*. Photograph of lower portion of right lung showing the tumor extending into the trachea. Although not well illustrated the massive growth is largely intrabronchial. *C*. Photomicrograph (×25) showing the nature of the intrabronchial tumor propagation, its fibrous cap covered by columnar epithelium but with focal metaplasia to stratified squamous epithelium. In the bronchial wall above is a spicule of bone. A lymph node at the upper left shows no tumor metastasis.

The right middle and upper lobes were atelectatic, contracted, firm, and anthracotic. The proximal ends of their large bronchi were filled by a cast of tumor

tissue which was continuous with the tumor in the right main bronchus. The tumor was attached here and there to the bronchial walls, and where not so attached its surface was smooth and pale.

The large arteries and veins of the lower lobe were firmly compressed but not visibly invaded by tumor. One right hilar lymph node showed direct invasion from contiguous tumor.

In general the tumor tissue was moderately firm and elastic, and was pinkish white.

The left lung showed a mucopurulent bronchitis, areas of atelectasis, and some irregular hyperemia and edema. In addition there was in the apex an area 2 by 1.5 by 1 cm. of fibroplastic and fibrocaseous tuberculosis with tuberculous bronchiectasis. Beneath this were several 5 mm. sized parenchymal tubercles. In the tracheobronchial lymph nodes were about a half-dozen well-encapsulated caseocalcareous tubercles from 3 to 5 mm. in diameter.

Microscopic examination revealed that the tumor was composed of small, uniform, polyhedral, cuboidal or low columnar cells, arranged occasionally in small sheets but usually in rows, single or several layers deep, on a fibrous stroma in a compact papillary form. Occasionally, also, there appeared to be small ducts or alveoli. The cells had a round or oval nucleus which was hyperchromatic with the chromatin showing little clumping. Mitotic figures were practically not to be found. The cytoplasm was scanty, clear, and very slightly acidophilic. There was no evidence of secretion. The stroma was widespread and in some places hyalinized. (Fig. 5*E*.)

This tumor formed a mass which propagated through the bronchial system, being adherent to the wall here and there. The intrabronchial tumor was capped in nearly all places by a layer of dense fibrous tissue, on which if epithelium was present it was generally stratified squamous. (Fig. 5*C*.)

The bronchi were dilated. Their epithelial lining was either replaced by granulation tissue, or it showed metaplasia to a stratified squamous type, or it less frequently remained pseudostratified columnar. The bronchial wall was frequently composed of dense fibrous tissue which was often hyalinized. Such bronchial walls were penetrated by tumor tissue only in the right lower lobe. The bronchial cartilages were separated. They sometimes showed invasion by tumor tissue. Frequently spicules of bone were found on or in close relation to bronchial cartilage, especially where perichondrium was infiltrated or elevated by tumor cells. (Fig. 5*D*.)

Except for operative sites and near the abscess cavity degenerative changes were not seen in the tumor.

There was no clew as to the exact point of origin of the tumor except that the greatest amount and degree of hyalinization of the stroma was near the center of the tumor in the lower lobe.

The lung parenchyma showed a remarkable chronic fibrosing pneumonitis, with foci of lymphocytes, fibrous tissue, and small cuboidal-cell-lined alveoli. Lipophages and macrophages filled such alveoli.

The chronic empyema cavities and the subjacent superficial lung abscesses showed tuberculous granulation tissue with focal caseation and miliary epithelioid tubercles. This appeared to be a recent superinfection, and there was no indication that the generalized pleural fibrous thickening was tuberculous in origin. There was no tuberculosis elsewhere in this lung.

Microscopic examination of the left lung and of the tracheobronchial lymph nodes confirmed the diagnosis already given. One right hilar lymph node showed tumor growing within its substance but it appeared to have invaded directly from tumor adherent to its capsule. Other bronchial nodes, in close proximity to neoplasm, showed no metastases.

Metastases were not seen grossly or microscopically in numerous sections of other tissues except for two tiny microscopic groups of cells, in portal triads of the liver, which resembled the cells in the lung tumor.

Anatomical diagnosis: Carcinoma of the bronchus (malignant adenoma type) arising in the right lower lobe. Propagation of tumor through the bronchial tree, and focal invasion of lung parenchyma. Metastases to a right bronchial lymph node and to the liver (microscopic). Extensive chronic atelectasis, pneumonitis and bronchiectasis. Chronic empyema (tuberculous?).

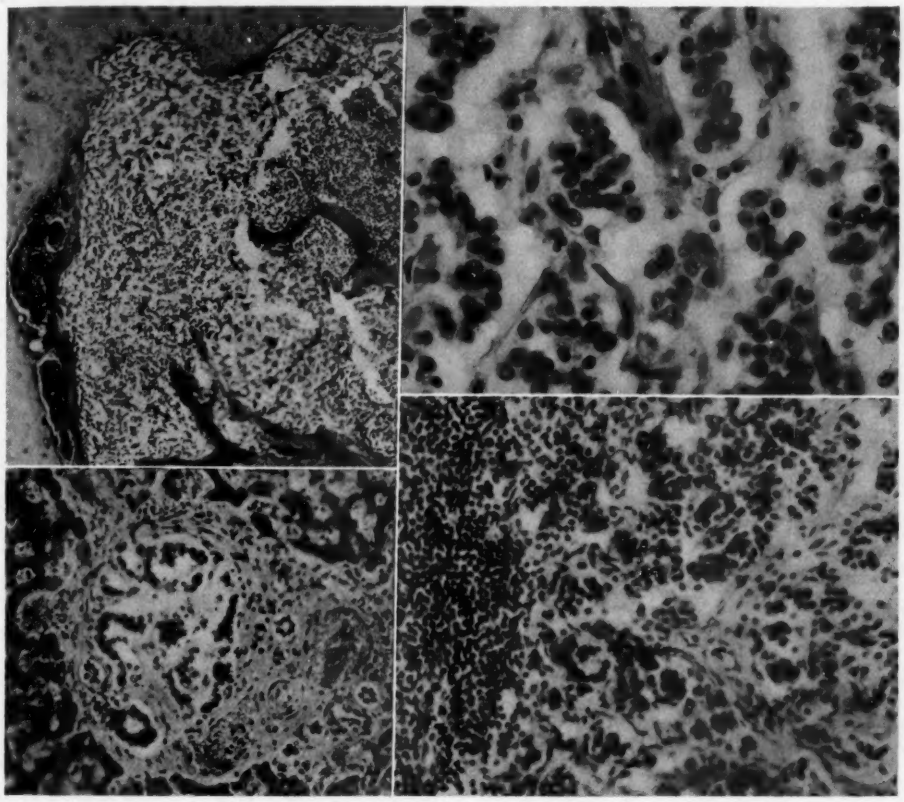


Fig. 5 *D*, *E*, *F*, and *G*.—Case 5. *D*. Photomicrograph (×58) showing tumor invasion of bronchial cartilage with destruction and elevation of perichondrium, and spicules of bone. *E*. Photomicrograph (×575) showing the nature of the tumor cells and their stroma. *F*. Photomicrograph (×165) showing a growth of abnormal, hyperchromatic epithelial cells resembling those in the bronchial tumor, growing in a portal area which also contains two normal-appearing bile ducts. *G*. Photomicrograph (×290) showing tumor in peribronchial lymph node.

DISCUSSION

A presentation of the clinical aspect of this type of tumor has been so thoroughly accomplished by Hamperl (1937),[8] Womach and Graham (1938),[7] Goldman (1940),[5] Brunn and Goldman (1940),[9] and others that only certain characteristics will be taken up in this discussion.

As seen in Table I, this tumor is as common in the female as in the male and occurs frequently in the third decade of life. These facts have been emphasized by most authors dealing with this subject. A

TABLE I

CLINICAL DATA

CASE	AGE	SEX	HISTORY ON ADMISSION	DURATION	PHYSICAL AND LABORATORY FINDINGS	X-RAY	BRONCHOSCOPY
1. W. W.	33	F	Persistent cough with repeated "colds" 5 yr.; *pneumonia* 6 mo. ago with repeated serious *hemoptyses* since	5+ yr.	Thin, anemic, lower right chest flat and no B.S.; sputum, hemolytic streptococci; Hb., 47%	Atelectatic bronchiectatic right lower lobe	Tumor filling bronchus of right lower lobe
2. L. M.	37	M	Attacks of coughing, fever and sweats and *hemoptyses* during past 2 yr.; pleurisy, general malaise, weakness	3+ yr.	Lower left chest flat; B.S.> râles; sputum, hemolytic streptococci	Left lower lobe collapsed	Rounded tumor mass in left lower lobe bronchus; bled easily on section
3. G. M.	62	F	Chronic productive cough; weight loss 35 pounds during a period of 1½ yr.; *pneumonia* 1924, 1931, and 1938; dry cough since 1932	2-8 yr.	Chronically ill and anemic, weak; lower right lung field flat with coarse râles; R.B.C., 3.64	Collapse of right lower lobe	Tumor mass which bled easily located in right lower lobe bronchus
4. J. D.	47	M	*Pneumonia* with slow recovery, 1924; repeated colds and productive cough, fatigability and weakness since (6 yr.) cough increased; weight loss 16 pounds	4-10 yr.	First admission, not acutely ill; chest quite normal; R.B.C., 3.85; very little sputum, no blood Second admission, 4 yr. later; acutely ill; signs of bilateral pneumonia; W.B.C., 34,000; pneumococcus Type VIII	First admission circumscribed shadow right upper lobe Second admission 4 yr. later same shadow as above, later obscured by pneumonia	In 1931 edematous bulging inward of origin of upper right lobe bronchus; microscopic section revealed tumor; no mitotic figures
5. M. G.	36	F	*Pneumonia* 15 yr. ago; empyema since then; slight cough; no hemoptysis or sputum; marked loss in weight and strength	15 yr.	Chronically ill; emaciated, anemic (Hb., 40%); rapid pulse; T., 100.8°; right chest shrunken; no B.S.; draining sinuses; clubbed fingers	Chronic empyema right with much shrinkage of chest wall; no aeration of right lung	Tumor almost completely filling lower end of trachea by extension from right main-stem bronchus

very noticeable clinical characteristic has been the repeated attacks of pneumonia over a period of several years. Recovery from these attacks has been the rule, a differential point between these and other more malignant lung carcinomata. Hemoptyses are frequently observed and are apt to be severe, the cause of which is easily explained by the pathologic characteristics. Other symptoms are variable and depend entirely on the basis of bronchial obstruction or infection of the lung subsequent to the obstruction. In some cases symptoms referable to the respiratory tract may be strikingly absent, even in the presence of a large tumor in a main stem bronchus.

Physical and x-ray findings are determined chiefly by the presence and extent of bronchial obstruction, lung infection, atelectasis, and other complications. A correct diagnosis can only be made following bronchoscopy with removal of adequate tissue for microscopic examination. Since all of these tumors arise in either the primary or secondary bronchi, they are readily visualized through the bronchoscope except when located in an upper lobe bronchus.

PATHOLOGY

An indication of the lack of universal opinion regarding the terminology of this lesion may be seen in the titles given by the following authors:

AUTHOR	DATE	TITLE
Geipel[10]	1931	Basal-cell cancer
Wessler and Robin[11]	1932	Benign bronchial adenoma
Kernan[6]	1935	Carcinoid
Moersch and Bowing[12]	1935	Adenocarcinoma
Clerf and Crawford[13]	1936	Benign glandular tumors
Zamora and Schuster[14]	1937	Vascular adenoma
Welt and Weinstein[15]	1937	Endothelioma
Hamperl[8]	1937	Cylindrome and carcinoide
Womach and Graham[7]	1938	Mixed tumors of the lung
Ochsner[16]	1940	Reserve-cell tumor
Goldman[5]	1940	Polypoid bronchial tumors

In all probability most of these authors have been describing the same type of tumor. A careful study of the five tumors in this report shows how some of the above titles may be justifiable.

The question arises as to what extent benign epithelial polypoid tumors of the bronchus can be separated from the slightly or ultimately malignant tumors. It is impossible at this time to determine if any bronchial polypoid tumor will remain continuously benign. To our knowledge no one has presented histologic criteria by which on biopsy it can be predicted how much of the tumor is within the bronchial lumen or to what extent direct invasion of the surrounding structures or distal spread of the tumor has taken place; furthermore,

TABLE II

PATHOLOGY

CASE	GROSS			MICROSCOPIC		
	SIZE	LOCATION	SECONDARY CHANGES	CELL TYPE	LOCAL EXTENSION	METASTASIS
1. W. W.	2 cm. diameter	Primary bronchus of right lower lobe	Bronchiectasis and atelectasis of entire lobe	Small deep staining cells with large nuclei; mitotic figures rare; cells arranged in cords and tend to form pseudoacini; free portion in bronchus covered by squamous epithelium	Invasion of bronchial wall	None found at operation
2. L. M.	2.2 by 1.4 by 1 cm.	Primary bronchus of left lower lobe	Bronchiectasis and atelectasis of entire lobe		Invasion of bronchial wall	None
3. G. M.	3.5 by 2.0 by 1.5 cm.	Primary and secondary bronchi of right lower lobe	Bronchiectasis of one-half of lobe and atelectasis of other one-half		Invasion of bronchial wall	To bone marrow
4. J. D.	6 cm. diameter	Primary and secondary bronchi of right upper lobe	Bronchiectasis of right upper lobe; pneumonia		Invasion of bronchial wall and to some extent the immediate surrounding parenchyma	To one tracheobronchial lymph node
5. M. G.	7 by 10 by 8 cm.	Extended up into trachea and involved entire right lung, chiefly by extension along air passages	Chronic empyema; obstruction of left primary bronchus		Invasion of walls of air passages and adjacent structures; *spread along* air passages	Mediastinal nodes adjacent to lung; liver

whether distant metastases, such as those found in three of the cases presented here, will subsequently occur.

A summary of the pathologic findings of our cases follows:

Analysis of these 5 cases shows that in the early stages the tumors were polypoid, intrabronchial growths. Later the main growth was still intrabronchial, with tumor permeation of portions of the bronchial tree, but in addition there were areas in which the tumor grew deep into or through the bronchial wall. They occluded the bronchus and produced local enlargement. The lung distal to the occlusion showed bronchiectasis, infection, and atelectasis.

Microscopically the tumors showed only minor differences. They were composed of fairly uniform polyhedral, cuboidal or low columnar, undifferentiated epithelial cells, which were arranged on an abundant stroma. The stroma was fairly vascular, sometimes hyalinized, and was reticulated or papillary. The cells were arranged on the stroma in one or more cell layers. Mitotic figures were not seen. Necrosis was not present. There was no evidence of secretion by the cells, and they were not argentaffine in the three cases in which this examination was made.

The free surface of the tumor was covered by a cap of dense connective tissue into which tumor cells sometimes penetrated. This surface in turn, if not ulcerated, was covered usually by stratified squamous epithelium even if the adjacent bronchial wall had retained its normal pseudostratified columnar epithelium. Deposits of fibrin were found on the surface after trauma by biopsy. The tumor infiltrated the bronchus at its base. Here there was an increase in fibrous connective tissue also, but it was less perfect as a capsule than that on the free surface. The bronchial cartilages were eroded by tumor.

In 3 of these cases bone was found in the tumor. It was in relation to bronchial cartilage from which it apparently arose. There was no evidence that it was tumor bone. The cartilage in or near all the tumors was bronchial cartilage.

Tumor cells were found in regional lymph nodes in 2 cases; the possibility that this might represent direct invasion rather than metastasis was not excluded in Case 5. In 1 case true metastases were discovered in the liver on microscopic examination, and in another a metastasis was discovered in a lumbar vertebral body on routine microscopic examination of the bone marrow.

TREATMENT

The lack of universal opinion as to the correct form of therapy for this type of tumor is probably due chiefly to misinterpretation or insufficient knowledge of its various characteristics. Experience has already been of some value in this respect. For example, bronchoscopic removal frequently has been followed by recurrence of the

TABLE III

THERAPY

CASE	BRONCHOSCOPIC REMOVAL	IRRADIATION	LOBECTOMY	PNEUMONECTOMY	RESULTS
1. W. W.	For biopsy only	--	Right lower 11/3/39	--	Returned to good health; no evidence of recurrence since operation on 11/3/39
2. L. M.	For biopsy only	--	--	First stage only	Died 2 wk. following operation of a fulminating empyema (left) and suppuration of left chest wall; hemolytic streptococci and other organisms
3. G. M.	For biopsy only	--	Right lower 6/27/40	--	Died 3 wk. after operation due to pulmonary embolism with infarction of right middle lobe, infection (pneumonia) and cardiac failure
4. J. D.	For biopsy only	Yes, Nov. '31 1300, R. U. Jan to Oct. 5131 R.U. 6431 R.U.	--	--	Died (10/20/34) of bilateral pneumonia (pneumococcus Type VIII) on sixth day after second admission and 4 yr. after first admission to hospital
5. M. G.	For removal of obstruction of left primary bronchus.	--	--	--	Empyema drained with marked improvement; expired of asphyxia on attempting bronchoscopic removal of intratracheal portion

tumor. Surgically removed lobes as well as autopsy specimens readily demonstrate why bronchoscopic removal may be not only difficult or impossible but also not without considerable risk. According to Brunn and Goldman,[9] Jackson and Konzelmann[17] and others, polypoid tumors of the bronchi may be either malignant or benign. Also, it has been amply demonstrated that bronchoscopic observation may not definitely determine which of the two types an individual tumor may be. Again, when a bronchial tumor projects into the lumen of the air passage, it is impossible to determine by bronchoscopic examination how much of the tumor is located outside of the bronchial wall. Thus, it seems reasonable to assume that bronchoscopic removal of bronchial tumors in general leaves much to be desired.

Until recent years surgical extirpation of lung tissue was attended by so great a risk that all lung tumors were treated either by bronchoscopic removal or by x-ray. After years of intensive investigation, treating hundreds of patients by this method, it has become generally believed and more recently quite definitely proved, that bronchogenic carcinoma has not been cured by x-ray therapy.[1, 2, 18]

With the development of a relatively safe technique for the removal of a lung lobe, an increasing number of lung tumors have been treated in this manner. Pneumonectomy has also made great strides in recent years. However, the risk attending the latter procedure is considerably higher than that attending the former. For this reason, it is obviously important to know which of the two operations should be used in this type of tumor. It is becoming more and more widely believed that the treatment should be based on the individual findings at the time of operation. When it appears likely that a lobectomy will remove adequately the tumor-bearing tissue, that is thought to be the operation of choice. When this is not possible a pneumonectomy should be performed.

As stated before, a great deal of confusion exists regarding the classification of the tumor under discussion. The marked variation in the microscopic appearance in different parts of the tumor is largely responsible for this lack of understanding. For this reason a small piece of tumor such as that taken through a bronchoscope for biopsy is apt to be very misleading in making a correct appraisal. Undoubtedly some reports of cures of highly malignant tumors by fulguration or x-ray may quite well have been on this basis.

Again, in order that statistics of surgical cures by excision may be more intelligently interpreted, sections should include the entire tumor for microscopic examination. It is only by this method of study that operative results may be evaluated according to the type of tumor involved.[19]

SUMMARY

A group of five cases of endobronchial tumor are reported which are characterized by a long clinical course with low-grade but very definite

malignant manifestations. Differentiation of benign from malignant epithelial tumors of the bronchi is not possible from bronchoscopic biopsy material alone since this offers no criteria as to the amount of tumor invading the surrounding structures or as to the presence of distal metastases. This is very strikingly demonstrated in a critical examination of the gross and microscopic material of the five cases reported. Treatment must be based on the assumption that these tumors are malignant or potentially malignant and should be removed by lobectomy or pneumonectomy. Because of the relative degree of risk associated with these operations, lobectomy should receive preference when it is sufficient for removal of the tumor-bearing tissue. In order that statistics of surgical cures of carcinoma of the lung may be more intelligently interpreted, sections for microscopic study should include the entire tumor. The group of tumors presented should not be confused with the highly malignant varieties.

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EXPERIMENTAL ATELECTASIS IN DOGS

Its Effect on Plasma Volume, Hemoglobin, Hematocrit, Blood Gases, Circulation Time, and Pulmonary Blood Flow

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AT PRESENT there is ample evidence to show that when lung tissue becomes atelectatic, the amount of blood it contains, the quantity of blood which passes through it per unit of time, and the rate of blood flow through it are all decreased.[1-9] It has also been shown that following the production of atelectasis there is a decrease in oxygen content and an increase in carbon-dioxide content of peripheral arterial and venous blood for a variable period of time.[2] Since many of these points have been shown in separate and in either acute or short-term experiments, the following study of experimental atelectasis was undertaken in order to correlate the findings in the blood gases, circulation time, hemoglobin, hematocrit, and in the proportion of the cardiac output passing through the atelectatic lung and to determine the total plasma volume in relation to the duration of atelectasis over a relatively long period of time.

METHODS

The oxygen and carbon-dioxide content of arterial and venous blood were determined by the gasometric method of Van Slyke and Neill.[10]* The hemoglobin concentration was determined by the photoelectrometric method of Evelyn.[11] The plasma volume (using the direct dye method) and the hematocrit readings were determined as described by Gibson and Evans.[12] The circulation time was determined by a modification of the method of Loevenhart, Schlomovitz, and Seybold,[13] 0.2 to 0.3 c.c. of a 0.5 per cent solution of sodium cyanide being injected into the right small saphenous vein in one series of observations, and into the right and left branches of the pulmonary artery in another series. A stop watch was used for timing the interval between the injection and the marked transitory increase in respiratory effort which constitutes the endpoint.

MATERIALS AND EXPERIMENTAL PROCEDURE

Young growing normal male and female mongrel dogs weighing from 8.8 to 27.2 kg. were used. Basal studies of plasma volume, blood gases, hematocrit, and circulation time were made one to eight days prior to division and closure of the left bronchus. Anesthesia was induced by the intravenous injection of sodium pentobarbital (nembutal) in doses

*In this part of the work we were assisted by the determinations of Dr. M. Pijoan.

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of 32.5 mg. per kilogram of body weight. The left fifth rib was resected subperiosteally under aseptic technique and the chest was opened. At this point, intermittent insufflation through an endotracheal catheter was instituted. The respirator was adjusted so that the carbon-dioxide content of the blood was maintained at a level just below that which caused spontaneous respiratory movements. The pleura over the left bronchus was incised and the bronchus was carefully isolated by blunt dissection and with minimal disturbance to the arterial and venous channels of the lung. The bronchus was then divided between hemostats by a scalpel, and the ends were treated with phenol and alcohol. In an attempt to avoid contamination by intratracheal and intrabronchial organisms, the insufflation was discontinued while the proximal stump was being inverted.[14] The ends were closed by inversion without ligation by means of purse-string sutures of silk, care being taken to avoid passing the needle into the lumen of the bronchus. Mattress sutures of fine twisted silk were used to reinforce the purse-string closure. At this time areas of discoloration indicating atelectasis were seen throughout the left lung. Closure of the wound was accomplished by a series of closely placed mattress sutures of fine silk in the posterior periosteum and pleura. Just before closure of the layers was completed, the right lung was inflated to minimize the possibility of pneumothorax. Pericostal sutures encircling the fourth and sixth ribs served to relieve tension on the wound. The remainder of the wound was closed by interrupted sutures of fine silk.

Persistence of the atelectasis was established beyond doubt by the division of the bronchus, by roentgenographs taken at intervals during the experimental period (Fig. 1), and by the demonstration of complete atelectasis at subsequent operation and autopsy. After the operation, the animals were kept in standard dog kennels on a well-balanced diet and were turned out of their cages daily for spontaneous exercise and activities.

Subsequent studies may be divided conveniently into three groups; in the first, determinations of total plasma volume, hemoglobin, hematocrit, blood gases, and circulation time were made within 6 to 33 days after the closure of the bronchus and at comparable intervals during the remainder of the experimental period.

The second group of studies was made after atelectasis had been present for periods varying from 58 to 198 days and consisted of determinations of oxygen and carbon-dioxide content of the peripheral arterial and venous blood immediately before and immediately after the inhalation of pure oxygen for a period of ten minutes.

The third series of studies was done within a few days after the second series and consisted of the following procedure: Under anes-

thesia as described for the bronchial division and closure, bilateral thoracotomy was performed. The animals were then placed so that the anterior-posterior diameter of the chest was vertical. Samples of blood from (1) the left ventricle, (2) the pulmonary artery, (3) a right pulmonary vein (aerated lung), and (4) a left pulmonary vein (collapsed lung) were obtained, and their oxygen and carbon-dioxide content was determined. While the samples were being withdrawn from the pulmonary veins, a bulldog clamp was placed on the vessels proximal to the site of the puncture to prevent aspiration of blood from the left auricle. The samples were obtained within as short a period of time as

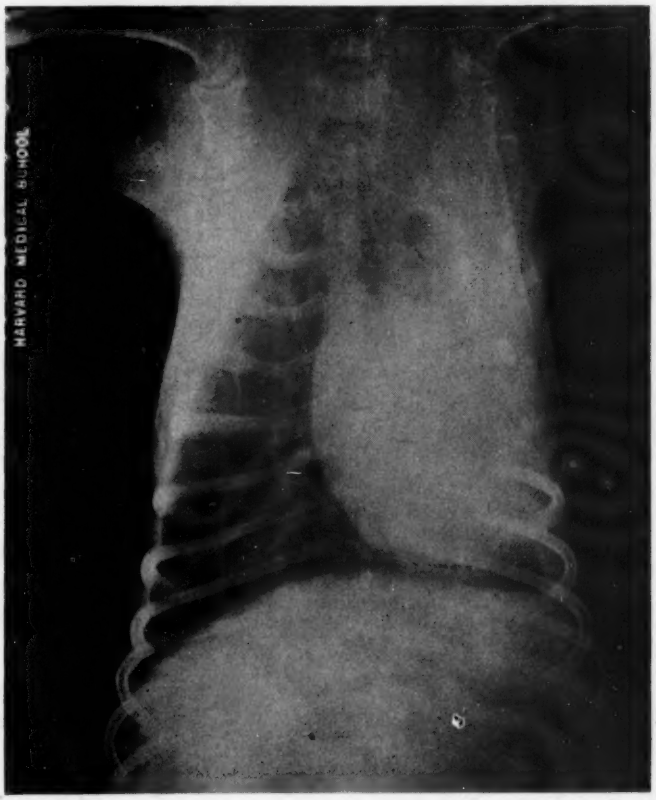

Fig. 1.—Roentgenogram taken one month after the production of atelectasis in Dog 4. The mediastinum is shifted to the left and the left half of the diaphragm is elevated.

possible; not more than five minutes elapsed between the withdrawal of the first and last (fourth) samples. With one exception (Dog 4), no change was made in the rate or amplitude of the impulses from the respirator or in the position of the animal during the withdrawal of samples. All samples except those from the right pulmonary veins were obtained through the left thoracotomy wound. Particular effort was made to minimize mechanical collapse of the aerated lung. After the blood samples had been collected, the circulation time through the aerated

TABLE I

WEIGHT, TOTAL AND UNIT VOLUME OF PLASMA, HEMATOCRIT, HEMOGLOBIN, CARBON-DIOXIDE AND OXYGEN CONTENT, OXYGEN CAPACITY, AND OXYGEN SATURATION OF ARTERIAL BLOOD; OXYGEN CONTENT AND SATURATION, CARBON-DIOXIDE CONTENT OF VENOUS BLOOD; AND LEG TO CAROTID SINUS CIRCULATION TIME IN DOGS BEFORE AND AFTER PRODUCTION OF EXPERIMENTAL ATELECTASIS

	POSTOPERATIVE INTERVAL IN DAYS	WEIGHT IN KG.	PLASMA VOLUME		HEMATOCRIT	HGB. IN GM. PER CENT	BLOOD GASES						CIRCULATION TIME IN SECONDS
							ARTERIAL			VENOUS			
			TOTAL IN C.C.	C.C. PER KG.			O_2 CONTENT	O_2 SATURATION	CO_2	O_2 CONTENT	O_2 SATURATION	CO_2	
Dog 1	*	11.0	464	42.0	51.9	15.3	17.5	85.0	40.8	11.0	53.0	44.0	11
	6	10.4	508	48.0	43.2	13.8	14.8	80.0	46.0	9.0	48.0	49.8	9
	34	11.7			58.0	14.7							7.5
	45	10.9	430	40.0	56.7	14.7							9
	85	10.4	476	44.7	56.7	19.3	22.2	85.6	41.88	15.2	58.0	45.2	8
	112	11.6	495	42.7	54.7	16.7	21.7	92.0	38.5	15.4	66.0	43.5	8.5
	140	11.9	513	43.1	54.3	19.3	22.3	88.0	42.0	15.3	59.0	45.0	9
Dog 2	*	10.9	642	59.0	37.6	12.1	15.0	92.0	36.0	10.1	62.0	40.0	13
	7	10.3	611	59.3	39.2	12.3	14.6	88.0	41.0	9.0	54.0	48.0	7
	15	10.2	537	52.6	44.0	12.8	14.7	86.0	42.0	10.0	57.0	48.0	
	41	11.2	550	54.0	43.7	15.3				11.5		39.3	12
	78	9.0	613	68.0	42.1	13.2	16.9	95.6	35.4	11.3	64.0	39.6	10
	105	9.5	623	65.0	40.1	12.8	16.4	96.0	32.0	10.8	63.0	39.7	9.5
	145	10.4	698	67.0	42.1	13.0	16.3	95.6	31.8	10.7	61.0	39.2	10
	198	12.0	671	56.0	43.0	14.9	17.6	88.0	37.8	12.7	63.0	43.0	11
Dog 3	*	13.6	550	40.4	51.7	14.5	16.0	82.5	41.0	9.8	50.0	47.0	10
	7	12.2	595	40.9	42.1	13.9	14.8	79.0	42.0	9.0	48.0	48.0	12
	33	12.8	550	43.0	47.0	13.1	14.9	84.0	45.0	10.9	60.0	47.6	8
	61	13.4	438	32.0	54.1	17.0	22.2	97.5	36.0	15.0	65.0	44.6	12
	103	13.9	543	39.0	52.4	17.9	20.1	83.7	42.0	13.2	55.0	49.7	9
	131	13.7	511	37.3	53.2	17.9	20.2	84.0	42.0	13.3	55.0	49.5	9
	153	14.2	555	39.0	50.4	14.8	17.6	89.0	38.0	14.3	70.0	45.0	11

*Preoperative basal levels.

Dog 4	*	13.1	485	36.7	50.2	14.6	16.9	86.0	37.4	14.1	70.0	39.7	10
	15	13.4	520	38.8	51.7	11.0	11.8	81.0	37.7				8
	48	15.7	628	40.0	51.9	16.0	18.7	82.0	33.3	13.8	60.0	37.5	10
	97	17.0	665	39.0	53.2	16.2	20.4	89.7	35.2	16.5	75.0	42.7	8
	146	18.7	782	41.8	52.3	16.0	20.4	89.0	35.0	16.5	72.0	42.0	8
	183	17.4	748	43.0	53.2	15.1	19.5	96.0	45.1	15.0	73.0	49.5	10
Dog 5	*	11.4	565	49.5	42.6	13.9	15.3	82.0	44.7	11.9	64.0	48.6	10
	14	11.9	548	46.0	43.7	10.4	11.7	84.0	36.9	6.8	48.0	43.5	11
	47	10.6	606	57.0	43.3	13.7	16.6	90.0	35.8	10.5	57.0	38.8	10
	82	11.9	652	54.7	44.8	13.7	17.3	94.0	35.7	13.7	74.0	41.0	9
	110	13.2	702	53.0	46.0	13.0	17.3	94.0	35.0	13.7	74.0	39.2	9
	138	13.9	720	51.8	42.9	13.7	17.3	94.0	35.2	13.0	70.0	39.2	9.5
	187	13.8	756	54.7	48.0	14.2	18.5	97.0	40.0	14.2	74.0	44.6	11
Dog 6	*	8.8	350	40.0	50.9	15.0	18.11	90.0	44.5	14.9	73.0	43.6	9.5
	33	8.2	352	40.0	45.3	12.4	16.0	91.0	47.0	12.1	69.0	49.8	7
	75	7.4	408	55.0	51.2	16.0	19.4	90.0	34.5	14.5	67.0	37.0	7
	96	9.6	369	40.0	55.5	17.7	20.7	87.2	35.2	15.7	61.0	45.0	8
	138	8.8	429	48.7	47.3	17.0	20.9	87.9	35.6	15.9	69.0	41.0	8
	182	9.0	485	54.0	49.0	14.4	17.9	93.0	41.5	14.8	70.0	40.0	9
Dog 7	*	22.7	1003	44.1	53.7	19.8	24.2	91.1	39.0	21.1	84.0	43.4	11
	6	21.1	1048	49.9	52.2	13.7	--	88.4	--	15.3	83.0	41.5	9
	48	23.4	938	40.0	57.9	13.7	16.4	89.4	39.0	15.3	83.0	43.2	11
	97	25.7	1047	40.7	57.0	13.6	17.1	96.0	41.0	15.2	83.0	47.7	11
Dog 8	*	14.6	727	49.9	52.3	18.4	17.8	82.4	44.0	15.3	62.0	--	11
	9	13.1	573	43.8	50.3	18.4	20.9	84.8	44.0	15.6	63.0	45.2	10
	58	15.0	560	36.0	56.0	16.1	21.2	98.0	45.2	13.7	62.6	50.0	11

and the atelectatic lung was determined by the injection of sodium cyanide into the right and left branches of the pulmonary artery, as described in detail elsewhere.[7] Just before closure of the second thoracotomy wound was completed, the aerated lung was inflated in an effort to minimize the possibility of pneumothorax. Seven to ten days later, the animals were sacrificed and appropriate studies of the tissues were made.

RESULTS

The results in the first group of experiments are shown in Table I. The variable changes in the unit volume (cubic centimeters per kilogram) of plasma, with the exception of three determinations in Dog 2, are within the range of normal volumes for intact dogs[15] and therefore cannot be regarded as significant. Both the hemoglobin and the hematocrit values were increased in four of the eight animals. Because these increases were associated with increases in weight they cannot be considered a result of the atelectasis, as it has been shown that there is a general tendency for increases in weight to be accompanied by increasing values for hematocrit and hemoglobin.[15] This is thought to be due to the increase in the proportion of muscle, a blood-rich tissue, in normal growing dogs.

In most instances there was a decrease in the oxygen content and an increase in the carbon-dioxide content of both arterial and venous blood following the production of atelectasis. After the production of atelectasis the oxygen content of peripheral arterial blood was found to be reduced in seven of the eight animals. The reduction varied from 2 to 29 per cent of the basal value. In Dogs 1, 2, 3, and 6 there was a concomitant rise in the carbon-dioxide content of the arterial blood ranging from 2 to 13 per cent above basal levels. Oxygen saturation was decreased in Animals 1, 2, 3, 4, and 7 in determinations made within a week after atelectasis began. In Dog 6 there was a slight increase in the oxygen saturation but this determination was made thirty-three days after bronchial division and closure. At that time in the postoperative course the oxygen saturation was probably increasing, as is seen in the figures for Dogs 3 and 5. The increase in oxygen saturation in Dog 8 is probably an artifact, as the initial saturation of 72.4 per cent is so low as to indicate a false value for this determination. Decrease in the oxygen content and the oxygen saturation and increase in the carbon-dioxide content of venous blood were seen in Dogs 1, 2, 3, and 6. In Dog 5 the decrease in oxygen content and saturation was accompanied by a decrease in the carbon-dioxide content. Carbon-dioxide and oxygen content were both decreased in Dog 7 while the oxygen saturation remained essentially unchanged.

Circulation time from the saphenous vein to the carotid sinus was found to be decreased in six of the eight animals when they were first

examined six or more days after atelectasis had been produced. In two animals there were slight increases at that time. In only one of the six animals did the decreases persist during the second month of atelectasis. In the other five animals which showed early decreases in circulation time these decreases disappeared during the second month and returned thereafter, only to disappear again after the fourth month of atelectasis (Fig. 2). It has been shown in acute experiments[7] that when one lung is rendered atelectatic the increase in the proportion of the cardiac output which passes through the aerated lung is accompanied by a decrease in circulation time through the aerated lung.

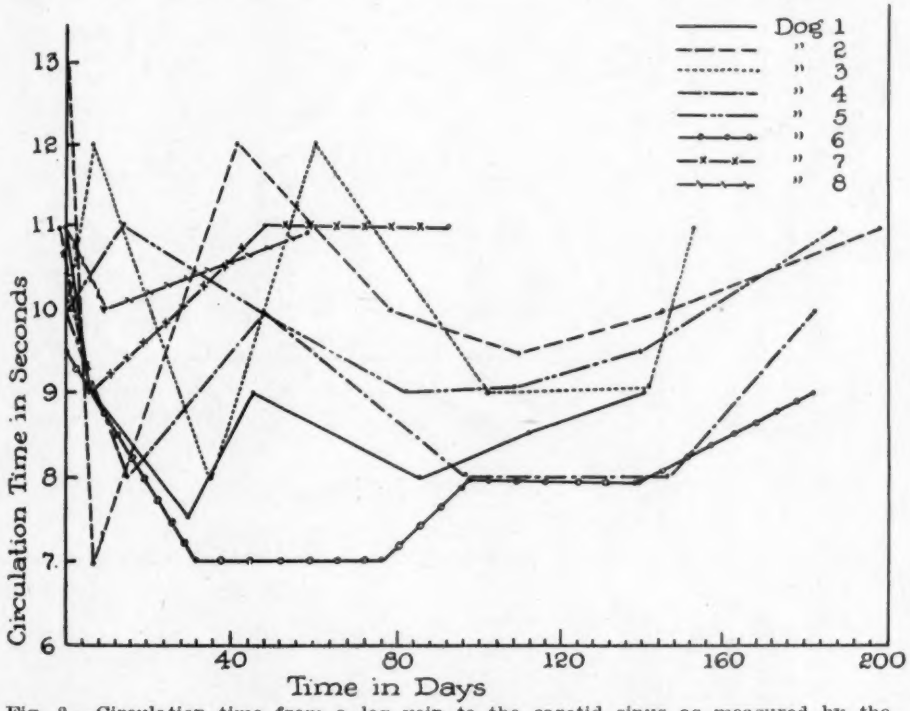

Fig. 2.—Circulation time from a leg vein to the carotid sinus as measured by the cyanide method in relation to the duration of atelectasis.

The effects of inhalation of pure oxygen for a period of ten minutes after from 58 to 198 days of atelectasis are presented in Table II. There followed in all animals, an increase in oxygen content of arterial blood which averaged 0.8 volumes per cent, or an increase of 2.3 per cent. In four of the seven animals there was a slight decrease in carbon-dioxide content of arterial blood which averaged 0.9 volumes per cent, or –0.46 per cent. Similar results were seen in the venous blood. The oxygen saturation of arterial blood was increased 4.4 per cent, while that of the venous blood was increased 4.0 per cent. These findings indicate that the degree of oxygen unsaturation found in the peripheral blood after many months of atelectasis is not entirely due to the admixture of arterial

TABLE II

HEMOGLOBIN, CARBON-DIOXIDE AND OXYGEN CONTENT, OXYGEN CAPACITY AND OXYGEN SATURATION OF ARTERIAL BLOOD AND OXYGEN AND CARBON-DIOXIDE CONTENT AND OXYGEN SATURATION OF VENOUS BLOOD BEFORE AND AFTER INHALATION OF PURE OXYGEN FOR PERIOD OF TEN MINUTES

	HEMOGLOBIN IN GM.	ARTERIAL CO_2 CONTENT	ARTERIAL O_2 CONTENT	ARTERIAL O_2 CAPACITY	ARTERIAL O_2 SATURATION %	VENOUS CO_2 CONTENT	VENOUS O_2 CONTENT	VENOUS O_2 SATURATION %	DURATION OF ATELECTASIS
Experiment 194, 4/9/37									
Before breathing pure oxygen	14.92	37.8	17.6	20.0	88.0	43.0	12.7	63.5	198 days
After breathing pure oxygen for 10 min.	15.0	35.5	19.8	20.1	98.5	41.9	14.7	70.0	
Experiment 200, 4/9/37									
Before breathing pure oxygen	14.85	38.6	17.65	19.9	89.0	45.0	14.3	71.4	153 days
After breathing pure oxygen for 10 min.	14.85	36.6	19.05	19.92	95.8	44.0	14.65	73.5	
Experiment 208, 4/21/37									
Before breathing pure oxygen	15.15	45.1	19.5	20.3	96.0	49.5	15.0	73.9	183 days
After breathing pure oxygen for 10 min.	15.15	43.9	19.8	20.3	97.5	49.0	15.25	74.8	
Experiment 209, 4/26/37									
Before breathing pure oxygen	14.25	40.0	18.55	19.1	97.0	44.6	14.24	74.5	187 days
After breathing pure oxygen for 10 min.	14.25	39.6	19.0	19.1	99.4	43.7	14.65	76.6	
Experiment 210, 4/21/37									
Before breathing pure oxygen	14.45	41.5	17.9	19.35	93.0	50.0	14.8	73.2	182 days
After breathing pure oxygen for 10 min.	14.45	41.4	18.6	19.35	96.0	49.0	16.15	83.0	
Experiment 230, 4/26/37									
Before breathing pure oxygen	13.6	41.0	17.15	18.2	94.0	47.7	15.2	83.5	97 days
After breathing pure oxygen for 10 min.	13.6	40.9	17.45	18.2	96.0	47.7	16.15	88.7	
Experiment 236, 5/3/37									
Before breathing pure oxygen	16.1	45.2	21.2	21.65	98.0	50.0	13.75	63.5	58 days
After breathing pure oxygen for 10 min.	16.1	45.2	21.32	21.65	98.5	49.5	13.99	64.6	
Average values before inhalation of O_2	--	41.3	18.5	--	93.0	47.1	14.28	71.9	
Average values after inhalation of O_2	--	40.4	19.3	--	97.4	46.4	15.07	75.9	
Average change		0.9*	0.8*		4.4	0.7*	0.79*	4.0	
Percentage of change		-0.46%	+2.3%			-0.67%	+1.8%		

*Volumes per cent.

and venous blood in the left auricle but depends to some extent on incomplete oxygen saturation of the blood passing through the aerated lung.

The third series of experiments yielded the results shown in Table III. Six animals had uneventful recoveries from the bilateral thoracotomy, one died on the operating table, and one died from postoperative sepsis. In two of the experiments the results were discarded because in one instance the heart action was failing while the blood samples were being withdrawn and in the other, due to deficient aeration, it was necessary to alter the rate of the respirator during the withdrawal of samples.

TABLE III

HEMOGLOBIN, CARBON-DIOXIDE, AND OXYGEN CONTENT, OXYGEN CAPACITY AND OXYGEN SATURATION OF BLOOD SAMPLES FROM (1) PULMONARY ARTERY, (2) RIGHT PULMONARY VEIN, (3) LEFT PULMONARY VEIN, AND (4) LEFT VENTRICLE IN RELATION TO DURATION OF ATELECTASIS, AND PROPORTION OF CARDIAC OUTPUT PASSING THROUGH ATELECTATIC LUNG

DURATION OF ATELECTASIS	DOG 1 142 DAYS	DOG 2 203 DAYS	DOG 3 159 DAYS	DOG 5 191 DAYS	DOG 7 106 DAYS	DOG 8 62 DAYS	AVERAGE
Pulmonary artery (1)							
Hemoglobin	16.06	15.9	15.4	14.7	13.55	14.4	
Carbon dioxide	41.6	45.2	42.3		49.2		
Oxygen	16.7	14.82	15.44	14.00	10.8	10.8	
Oxygen capacity	21.52	21.3	20.6	19.7	18.2	18.90	
Oxygen saturation	79.3%	69.5%	75.0%	71.0%	59.4%	67.2%	70.2%
Pulmonary vein from right (aerated) lung (2)							
Hemoglobin	16.06	15.75	15.4	14.75	13.55	14.15	
Carbon dioxide	28.1	42.0	35.2		44.0		
Oxygen	21.5	18.6	20.0	19.15	16.35	17.05	
Oxygen capacity	21.52	21.15	20.6	19.8	18.2	18.95	
Oxygen saturation	99.5%	88.0%	97.0%	97.0%	90.0%	90.0%	93.6%
Pulmonary vein from left (atelectatic) lung (3)							
Hemoglobin	16.06	15.52	15.6	14.62	13.65	14.19	
Carbon dioxide	41.0	45.2	46.3		50.0		
Oxygen	15.25	14.1	15.45	14.25	10.7	12.5	
Oxygen capacity	21.52	20.8	20.9	19.6	18.3	19.0	
Oxygen saturation	77.0%	68.0%	74.0%	72.0%	59.4%	65.8%	69.3%
Left ventricle (4)							
Hemoglobin	16.4	15.52	15.4	14.75	13.55	14.4	
Carbon dioxide	30.2	42.6	36.0		45.1		
Oxygen	21.3	17.22	19.15	19.1	16.45	16.0	
Oxygen capacity	22.0	20.8	20.6	19.8	18.2	18.90	
Oxygen saturation	97.0%	83.0%	93.0%	96.4%	90.02%	85.0%	90.7%
Proportion of cardiac output through atelectatic lung	6.6%	25.0%	17.3%	2.4%	22.1%	20.6%	15.6%

As expected, oxygen content and saturation were highest in the blood from the aerated lung. The saturation in these samples varied from 88 to 99.5 per cent, with an average of 93.6 per cent. The lowest values for oxygen content and saturation were, of course, in the samples from the pulmonary artery and a left pulmonary vein (collapsed lung),

and averaged 70.2 and 69.3 per cent respectively. With the exception of the values for Animal 1, these findings are within the range of normal levels found by Stewart.[16] Their close agreement (within 1 per cent) renders improbable any significant communication between the pulmonary and the bronchial arterial systems in the atelectatic lung.

The oxygen content and saturation of blood from the left ventricle were variable, depending on the admixture of oxygenated and unoxygenated blood. The figures for oxygen saturation ranged from 85 to 97 per cent and averaged 90.7 per cent. Figures for the carbon-dioxide content of blood from the left ventricle were, in general, higher than those for samples from the aerated lung and lower than those for the samples from the atelectatic lung and the pulmonary artery.

From the figures for oxygen saturation of blood from (1) the left ventricle, (2) a pulmonary vein from the collapsed lung, and (3) a pulmonary vein from the aerated lung, the relative amounts of blood flowing through each lung may be calculated by means of the formula used by Weiss:[17]

$AX + VY = M(X + Y)$ when:

X = percentage of total pulmonary blood flow through the aerated lung

Y = percentage of total pulmonary blood flow through the atelectatic lung

$X + Y = 100$ percentage of the pulmonary blood flow

$X = 100 - Y$

A = oxygen saturation of blood from the aerated lung

V = oxygen saturation of blood from the collapsed lung

M = oxygen saturation of blood from the left ventricle

The calculation for Dog 2, for example, is as follows:

$$88X + 68Y = 83(X + Y)$$
$$8800 - 88Y + 68Y = 8300$$
$$-20Y = -500$$

$Y = 25$ which is the percentage of the cardiac output flowing through the atelectatic lung

$X = 75$ which is the percentage of the cardiac output flowing through the aerated lung

The results in Animals 2, 3, 7, and 8 indicate that between 17 and 25 per cent of the cardiac output passed through the atelectatic lung. The average amount of blood flowing through the atelectatic lung in these four animals was 22 per cent and in the six animals in which the experiment was considered satisfactory, values averaged 15.6 per cent.

Adams[1] employed this method for determining blood flow through lungs made atelectatic for periods varying from one day to ten weeks, by chemical stenosis of the bronchus. In a series of seven animals he found that from 28.5 to 40 per cent (average, 32 per cent) of the total pulmonary blood flow passed through the atelectatic lung. His values are somewhat higher than those presented here and it is

believed that the longer period of atelectasis in our series of experiments has been accompanied by progressive alveolar and capillary collapse and consequently greater decreases in the blood flow through the atelectatic lung.

The effect of chronic atelectasis on the circulation time through the lungs is shown in Table IV. An average of 19.5 seconds was the time necessary for an adequate dose of sodium cyanide to be carried through the atelectatic lung from the point of injection (left branch of the pulmonary artery) to the carotid sinus.[18, 19] When the injection was made into the branch of the pulmonary artery leading to the aerated lung, the average time elapsing before the end point was 9 seconds. The time necessary for sodium cyanide to cause the end point when injected

TABLE IV

PULMONARY CIRCULATION TIME IN RELATION TO DURATION OF ATELECTASIS AND TO PULSE AND RESPIRATORY RATES AS DETERMINED BY INJECTION OF SODIUM CYANIDE INTO RIGHT AND LEFT BRANCHES OF PULMONARY ARTERY

ANIMAL NO.	DURATION OF ATELECTASIS IN DAYS	PULSE RATE	RESPIRATORY RATE	DOSE OF 0.5% SOLUTION OF NACN IN C.C.	CIRCULATION TIME THROUGH ATELECTATIC (LEFT) LUNG IN SECONDS	CIRCULATION TIME THROUGH AERATED (RIGHT) LUNG IN SECONDS
2	203	114		0.18	25.0	
3	159	132		0.18	25.0	9
4	185	72	48	0.25	16.5	11
5	191	128	40	0.2	13.5	8
7	106	156	26	0.2	20.0	7
8	62			0.2	17.0	10
Average					19.5	9
Average	Circulation time from pulmonary artery to carotid sinus				5.0	5
Average	Net pulmonary circulation time*				14.5	4

*The term, "circulation time through the lungs," used here is defined as the time calculated to be necessary for the passage of blood from either branch of the pulmonary artery to the left ventricle.

into the left ventricle in dogs of similar size and under comparable experimental conditions is 5 seconds,[7] and when this is subtracted from the above average figures, the "net pulmonary circulation time"* is 14.5 seconds through the atelectatic lung and only 4 seconds through the aerated lung. It has been shown[7] that within an hour after atelectasis has been produced, the net pulmonary circulation time through the atelectatic lung will be increased from an average normal value of 4.2 seconds to an average value of 6.2 seconds. Accompanying this is a decrease in the net pulmonary circulation time through the aerated lung from a normal average value of 4.6 seconds to an average value of 2.8 seconds. These control values are presented to show that the prolongation of atelectasis with progressive capillary and alveolar collapse leads

*The term "net pulmonary circulation time" used here is defined as the time calculated to be necessary for the passage of blood from a branch of the pulmonary artery to the left ventricle.

to marked decrease in the rate of blood flow through the collapsed lung. However, the increase in the speed of blood flow through the aerated lung, seen soon after the production of atelectasis, does not persist but is followed by a return to normal values within six months.

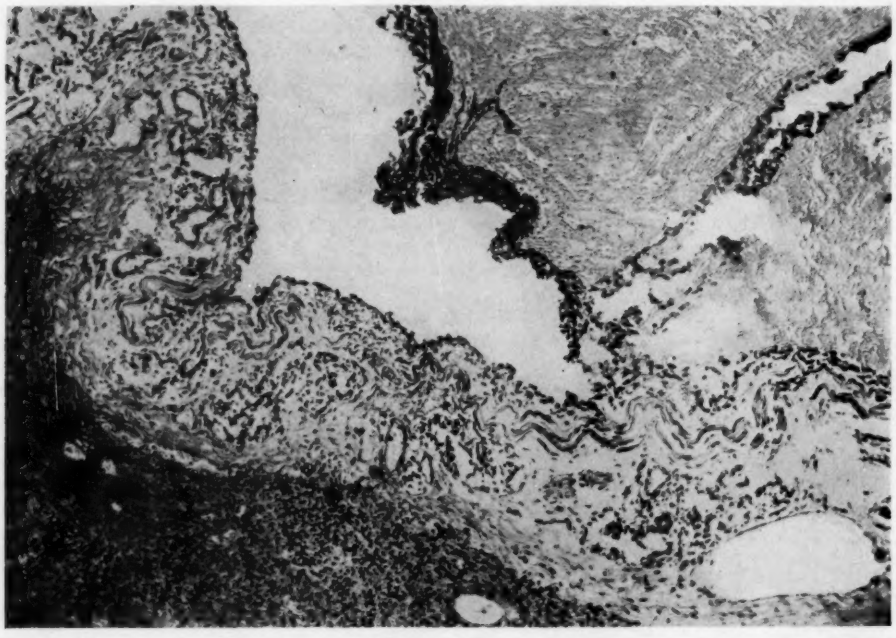

Fig. 3.—Section of dilated bronchus filled with mucoid material and macrophages. The wall of the bronchus is edematous and is infiltrated by plasma cells, lymphocytes, and a few polymorphonuclear leucocytes. Leucocytic infiltration and scarring extend for a short distance into the parenchyma.

The significant findings at autopsy were confined to the chest. The heart and left lung were found to occupy the left half of the thorax. The atelectatic lung was bluish purple and, in most of the animals, it was adherent to the chest wall along the thoracotomy wound. In three of the animals additional areas of adhesions were found over the costal surfaces but none was extensive. Some adhesions were also present on the mediastinal surface near the hilus. The main vessels at the hilus appeared to be decreased in size when compared to those of the opposite side. The divided ends of the bronchus were adherent to each other in some of the animals but in none was there a communication between them. The obstructed left main bronchus and its branches were filled with mucoid material. No areas of suppuration were seen on gross examination.

The principal points of interest in the microscopic examination were found in the collapsed lung (Figs. 3, 4, and 5) to which the following description, in general, applies. The bronchial radicals were dilated and contained bluish pink staining mucoid material in which varying numbers of macrophages were seen. The walls of the bronchial branches

were thickened by deposits of moderately dense fibrous tissue and were infiltrated by plasma cells, lymphocytes, and a few polymorphonuclear leucocytes. These changes extended for a short distance into the adjacent parenchyma. In some areas the bronchial mucosa was unchanged but in others it was represented by a very thin layer of cells. The parenchyma of the lung away from the bronchial tree was singularly free from scarring, fibrosis, and inflammatory reaction. The alveoli were uniformly collapsed. In some areas red blood cells were seen lying in the alveolar spaces. Many of them were partially hemolyzed and hemosiderin had been deposited in phagocytes which were either macrophages or were possibly derived from the alveolar walls. The presence of these cells in the alevoli made the lung more solid than could be accounted for by the atelectasis alone. No evidence of communications between the blood and the air channels was found in the study of these sections. The quantity of blood in the alveolar spaces was small compared to the potential capacity of the spaces and apparently was the result of diapedesis.

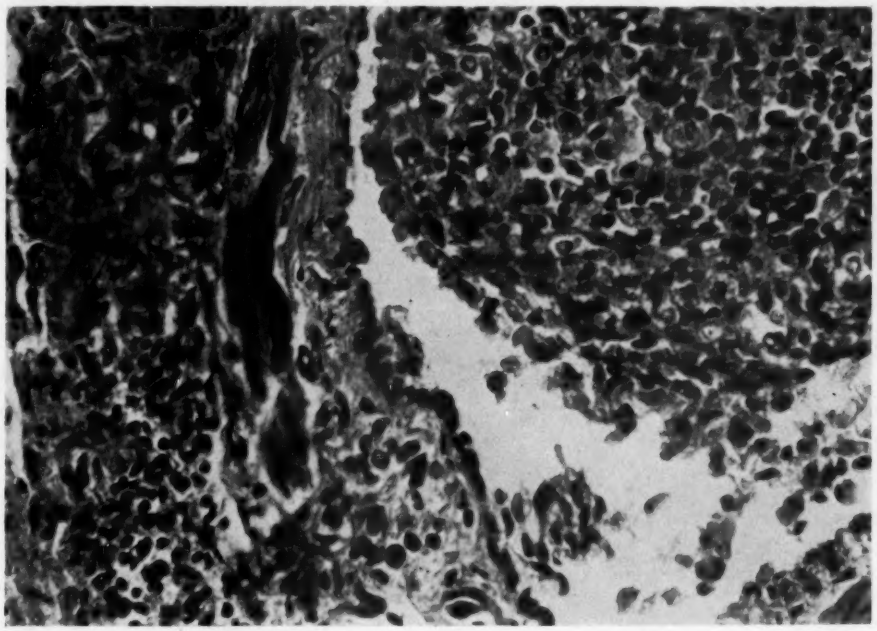

Fig. 4.—The bronchial wall is thick and is infiltrated with lymphocytes and macrophages. There is beginning fibrous tissue replacement of the muscular coat. The lumen contains an inflammatory exudate.

Adams[1] found dilated spaces filled with apparently normal blood in the lung parenchyma within two months after the production of atelectasis by chemical stenosis of the bronchus. At the end of six months these spaces were present in large areas of the lung and also surrounding the larger bronchi. Of the animals studied here, four had atelectasis for six months or longer, two had atelectasis for more than

five months, and the other two for approximately two months. The sections from these animals represented portions of lung both from the periphery and from areas surrounding the larger bronchi, yet no blood spaces such as those described by Adams were found.

SUMMARY

The principal changes which follow the production of experimental atelectasis in dogs by the division and closure of a bronchus may be summarized as follows: Within a few minutes after the bronchus is divided the blood circulating through the corresponding lung begins to absorb the contained gases and there appear areas of discoloration indicating atelectasis. This process continues until practically no gases remain in the lung, which then resembles a solid organ such as the liver. During this time there is a shift of blood flow from the atelectatic to the aerated lung. Thereafter for a period of weeks sufficient blood flows through the collapsed lung to cause a variable degree of oxygen unsaturation of peripheral arterial blood due to the admixture of oxygenated and unoxygenated blood in the left auricle. However, this degree of arterial anoxemia is not sufficient to cause any significant increase in hemoglobin, hematocrit, or total plasma volume. The proportion of the cardiac output which passes through the atelectatic lung decreases, causing an increase in the oxygen saturation of peripheral blood, and after a period of from six to eight weeks there is a negligible degree of oxygen unsaturation in the resting animal.

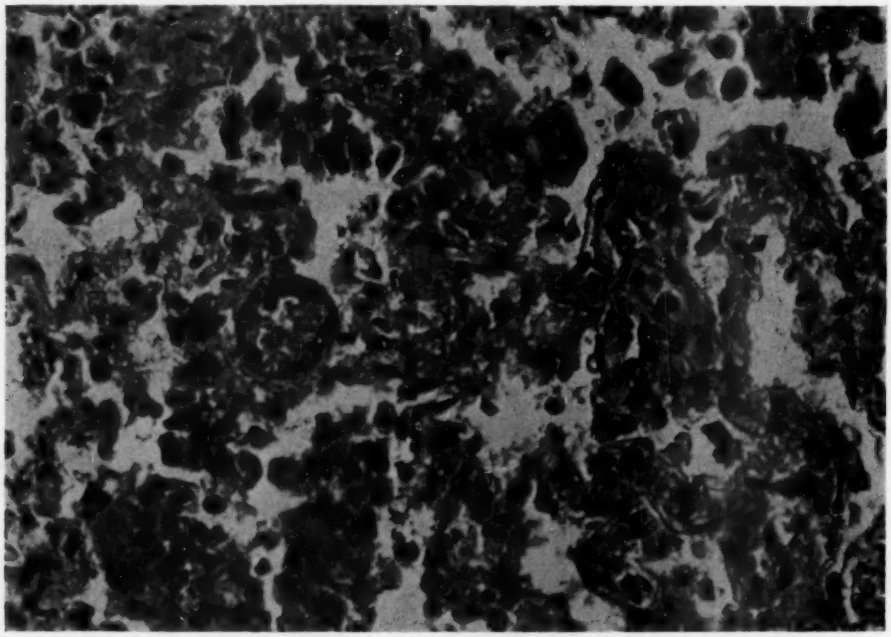

Fig. 5.—Lung parenchyma showing uniformly collapsed alveoli. Macrophages containing ingested material are present in the shrunken alveolar spaces.

Early in the course of the atelectasis the circulation time from a leg vein to the carotid sinus as determined by the injection of sodium cyanide is decreased but tends to return to basal values during the second month of atelectasis. At this time the blood gases also return to basal levels. During the fourth month of atelectasis there is a second decrease in the leg to carotid sinus circulation time but it is unaccompanied by any alteration in the blood gases. A second return to basal levels of circulation time is found during the fifth or sixth month. Since the greater part of the cardiac output passes through the aerated lung, most of the sodium cyanide passes through it also. The values for circulation time determined in this way consequently indicate the rate of blood flow through a vascular circuit of which the aerated lung forms a part. The changes in the circulation time are therefore thought to be due to alterations in the rate of blood flow through the aerated lung rather than to increased rates of flow in the peripheral vascular system. It has been shown in acute experiments that the rate of blood flow through a lung recently rendered atelectatic is decreased. By direct studies of the circulation time through the atelectatic lung it has been demonstrated that the continued state of atelectasis is accompanied, after several months, by further decreases in the amount and velocity of blood flowing through the affected lung, these decreases being brought about most probably by progressive alveolar and capillary collapse.

The degree of oxygen unsaturation in the peripheral arterial blood accompanying atelectasis of from 58 to 198 days' duration has been shown to be due to two factors: (1) the unsaturation of blood passing through the aerated lung and (2) the admixture of oxygenated blood from the aerated lung and unoxygenated blood from the collapsed lung. In the same animals, after these periods of atelectasis, by studying the oxygen saturation of blood from the functioning lung, from the collapsed lung and from the left ventricle, the amount of blood passing through the atelectatic lung during intermittent insufflation of the opposite lung with the chest open was found to average 15.6 per cent of the cardiac output.

CONCLUSIONS

Atelectasis of one lung of from 58 to 198 days' duration produced experimentally in dogs results in the following:

1. A variable decrease in the oxygen saturation and a less constant increase in carbon-dioxide content of arterial and venous blood in resting animals. These changes persist for a period of from four to six weeks.

2. No significant changes in the hemoglobin, hematocrit, or in the total plasma volume.

3. A decrease in the leg to carotid sinus circulation time during the first month of atelectasis, a return to basal levels during the second

month, a secondary decrease during the fourth month, and a secondary return to basal levels during the fifth or sixth month.

4. Oxygen unsaturation of peripheral blood which is due to two factors: (1) oxygen unsaturation of blood passing through the aerated lung and (2) admixture of oxygenated blood from the aerated lung and unoxygenated blood from the collapsed lung.

5. A decrease in the proportion of the cardiac output which passes through the atelectatic lung. After 58 to 198 days of atelectasis only an average of 15.6 per cent of the cardiac output passes through the atelectatic lung when the chest is open and the other lung is insufflated intermittently.

6. A decrease in the size of the corresponding pulmonary vessels, uniformly collapsed alveoli containing partially hemolyzed red blood cells and phagocytes containing hemosiderin, an accumulation of mucoid material in the bronchial radicals and thickening and chronic inflammatory changes in their walls and no scarring, fibrosis or inflammatory changes in the lung parenchyma except immediately adjacent to the bronchial tree.

We wish to express our appreciation to Dr. Edward L. Burns for his assistance in the interpretation of the microscopic findings and in the preparation of the photomicrographs.

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SOME OBSERVATIONS ON ACUTE RENAL HYPERTENSION

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IN 1836, Bright first suggested that hypertrophy of the heart found in patients dead of kidney disease might be secondary to the increased pressure or resistance offered by the kidneys against which the heart was forced to drive in order to maintain the circulation. Blood pressure was not mentioned, but the implication was obvious, and since that time numerous investigations have been made of the relationship between disorders of the kidney and arterial hypertension.

The earliest studies concerned statistical analyses of the relationship between disease in the kidney and clinical hypertension. They were enhanced by the introduction of a convenient method for determining the blood pressure in man by Riva-Rocci in 1895. The data were confusing, however, and it was practically impossible to distinguish between cause and effect. Further advance in the problem had to await the development of applicable laboratory techniques.

Tigerstedt and Bergmann (1898) demonstrated that saline extracts of the kidney induced a rise in the blood pressure when injected intravenously into the experimental animal. Though others at first were unable to obtain such positive data, satisfactory confirmation was reported by Bingel and Strauss (1909) and by Bingel and Claus (1910). These observations were confirmed and further extended by Landis, Montgomery, and Sparkman (1938). At best, however, this evidence that the kidneys contain substances capable of elevating the blood pressure in experimental animals is quite indirect as far as the relationship between the kidney and clinical hypertension is concerned.

Recently important advances have been made by the use of methods devised to induce hypertension by interfering with the circulation of the kidney (see Goldblatt, 1938, for references). The method of inducing partial ischemia of the kidneys (Goldblatt and associates, 1933) and that of producing a constrictive perinephritis by means of cellophane (Page, 1939) have been the most consistent in producing hypertension experimentally and have yielded, to date, the most valuable information concerning the role the kidneys play in experimental and clinical hypertension.

The fact that hypertension in man may exist in the absence of any anatomical or functional evidence of disease of the kidneys has been offered repeatedly as evidence that the kidneys play no significant part in clinical hypertension. This criticism has lost its weight, however, in

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the light of observations upon experimental hypertension due to renal ischemia. It is now generally accepted that in this type of experimental hypertension, there may be no demonstrable variation from the normal anatomic structure or function of the kidneys. Controls have demonstrated that hypertension will result from partial ischemia of the kidney irrespective of its innervation. The presence of the adrenal medulla is not necessary, but the adrenal cortex is essential. The large body of evidence indicating that the partially ischemic kidney exerts its effects through a humoral mechanism has been reviewed by Page (1940). Analysis of the available data by Munoz and co-workers (1940) and independently by Page (1940) and others has yielded schemata indicating the mode of formation of the substances producing hypertension after renal ischemia. The schemata show a remarkable similarity in spite of differences in nomenclature. Finally, Page and Helmer (1940) reported the isolation and crystallization of the pressor substance as the oxalate and picrate.

The principal goal in clinical investigation is the application of relevant data to the eradication of disorders in man or to the relief of their effects. In the case of human hypertension there are gaps in the knowledge not only concerning the role played by the kidneys but also concerning the details of the production and the nature of the humoral substances involved. Nevertheless, encouraging steps have already been taken in the direction of controlling at least the symptoms and signs of hypertension in man (*cf.* Grollmann, Williams and Harrison, 1940; Page and associates, 1941). These attempts at therapy with extracts of normal kidneys were stimulated by the knowledge that the normal kidney inhibits or counteracts the actions of the substances liberated by the ischemic kidney. Page and his co-workers (1941) have reported suggestive preliminary results from the oral administration of renal extracts in cases of malignant hypertension.

Further progress in the etiology and therapy of hypertension awaits an increased understanding of the nature of the products of the ischemic kidney, their biologic effects, and the mechanism by which the normal kidney or its extracts counteract the effects of the ischemic kidney.

Most of the observations in the past have been made on the effects of long-standing partial ischemia of the kidneys, or on test animals into which extracts of normal or ischemic kidneys have been injected. It was thought desirable to study the immediate effects of short-lasting but total ischemia of the kidney not in a second test animal, but in the same animal. In addition to obtaining data concerning the systemic effects of substances produced by or in the ischemic kidney, it was planned to become sufficiently familiar with the technique to evaluate its usefulness for testing the effects of crude extracts or of purified substances upon the results of injecting the products of the ischemic kidney. This paper concerns the results of these experiences.

MATERIAL AND METHOD

The experiments were performed upon 10 adult cats and upon 7 adult dogs weighing 7 to 12 kg. All experiments were done under urethane anesthesia (1.5 to 1.75 Gm. per kilogram intravenously) induced slowly and usually with the animal under a preliminary ether anesthesia. Records of the blood pressure were made from the carotid artery, usually the right. The contralateral carotid artery was ligated to exclude the carotid sinus from the circulation. Both vagi and both cervical sympathetic trunks were severed in the neck. In 2 dogs in which the heart had been denervated at a previous operation, the inferior cervical ganglia were excised along with the vagi through the base of the neck at the time of the experiment.

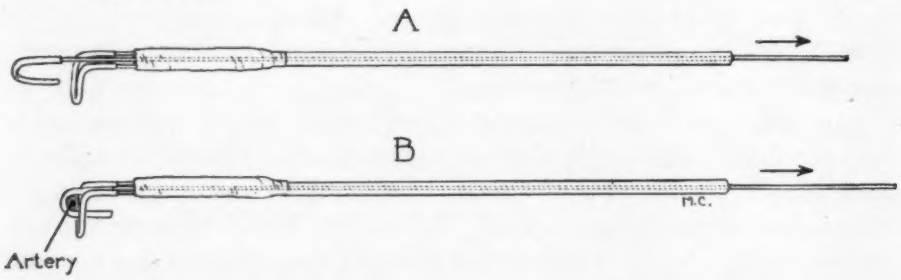

Fig. 1.—Clamp used for occluding the aorta or renal arteries (constructed by Miss E. M. Bright). The clamp was set by a screw-clamp holding the style against its sheath after having drawn it up to occlude the vessel.

Sudden complete ischemia of the kidneys was produced by means of delicate rubber-covered adjustable clamps (Fig. 1). In every case the kidneys were exposed through either a single upper abdominal midline incision or each kidney separately through a subcostal flank incision. Both kidneys were always thoroughly freed from the perinephrium to interrupt any accessory blood supply reaching the kidney through its cortex from the perinephrium. The dissection included clearing the renal pedicle so as to denervate the kidney. In 3 cats and 1 dog the clamp was applied on the aorta above the origin of the renal arteries after ligating it below the origin of the arteries. In all of them the adrenal glands were removed acutely to eliminate the effects of ischemic adrenal glands. In the rest of the animals the clamps were applied one to each renal pedicle including all the arterial branches to the kidney and excluding the veins.

In 2 dogs it was desired to test the humoral effects upon the heart of releasing the totally ischemic kidney. For this purpose sympathetic denervation of the heart was carried out as described by Cannon and his co-workers (1926). The vagi and the inferior cervical ganglia were resected acutely at the time of the experiment one and two months after the sympathetic denervation. In 1 of these animals the right adrenal gland was removed and the left demedullated at the first stage of

denervation of the heart. In the other the right adrenal gland was excised at the time of the first stage of cardiac denervation and the other was removed acutely at the time of the experiment six weeks later. In both these animals central stimulation of the sciatic nerve increased the heart rate by only four to six beats per minute when this test was made before the acute experiment was begun.

In 2 of the cats the spinal cord was transected at the level of C7 to provide a low initial blood pressure and to avoid reflex effects. This procedure proved unsatisfactory and will be discussed below (*cf.* effects of low initial pressure).

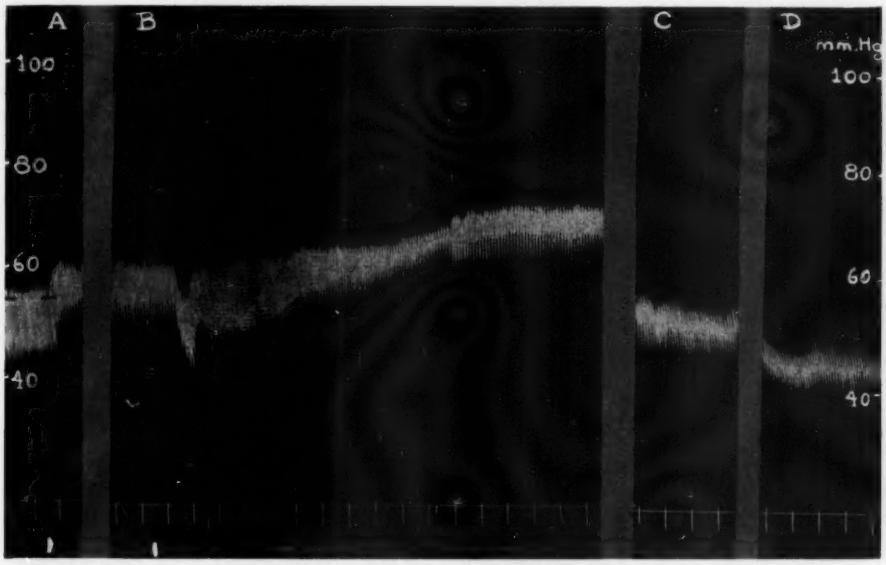

Fig. 2.—Dog 1 (Aug. 8, 1940). Urethane anesthesia (1.75 Gm. per kilogram). Tracing of blood pressure with Hürthle manometer calibrated against mercury manometer. Scales at right and left represent blood pressure in millimeters of mercury. Both vagi cut in neck. Adrenal glands removed acutely. Aorta ligated below origin of renal arteries. At first signal, clamp was applied to aorta above level of origin of renal arteries; at second signal, clamp was released. Note passive rise and fall of the blood pressure with application and release of clamp. The heart rate at the maximum rise was 206 per minute, during the fall, 210 per minute. Interval between *A* and *B*, 4 minutes; between *B* and *C*, 22½ minutes; between *C* and *D*, 8½ minutes. Time signal, 30 seconds.

The blood pressure records were made on a smoked-drum kymograph by means of a rubber-membrane Hürthle manometer and in the 2 dogs in which the heart was denervated and the adrenals removed, by means of the direct mercury manometer.

RESULTS

1. *Repeatability of the Pressor Response.*—A rise in blood pressure was obtained in 5 of the 10 cats after release of the occluded renal arteries. The cause for the failures will be discussed below. A rise in blood pressure upon release of the occluded renal pedicle was obtained in every one of the 7 dogs tested.

2. *Relationship Between Duration of Ischemia and Magnitude of Pressor Response.*—The shortest period of occlusion tested was three minutes. This produced a definite rise in blood pressure after release of the clamps in the dog but not in the cat. The rise in blood pressure was only about 10 mm. of mercury, however, and its duration was not longer than ten to fifteen minutes. Ischemia of five minutes' duration led to hypertension in both cat and dog. Occlusion for periods of ten minutes produced blood pressure rises which were similar in degree and duration to the pressor responses after periods of occlusion lasting longer than ten minutes (Figs. 2 and 3). The longest occlusion was for five and one-half hours.

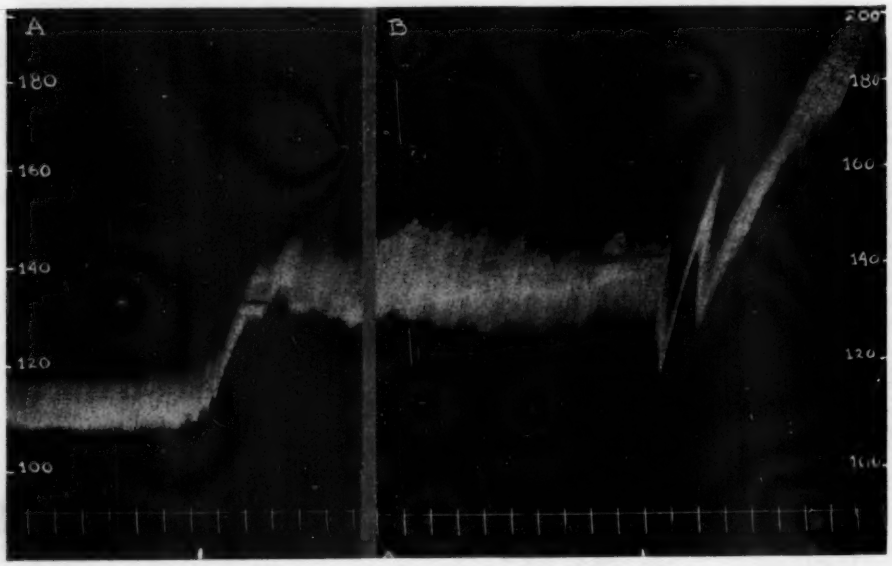

Fig. 3.—Dog 2 (Aug. 16, 1940). Preparation as in Fig. 2 except that clamps were applied to renal arteries instead of aorta. First signal: both renal pedicles clamped (excluding veins), for 74 minutes. Second signal: clamps released. Note composite character of pressor response (see text). Interval between *A* and *B*, 67 minutes. Time signal, 30 seconds.

The average blood pressure rise obtained in the cat was 30 mm. of mercury. The maximum rise was 40 mm. of mercury after both renal pedicles were clamped for five hours. A rise of 33 mm. of mercury was obtained after the pedicles were clamped for only ten minutes. The average blood pressure rise obtained in the dog was 40 mm. of mercury. The maximum rise was 80 mm. of mercury after the arteries to the kidneys were clamped for 105 minutes (Fig. 4). In general, beyond the period of ten minutes the duration of the renal ischemia had no consistent influence upon the degree of rise in blood pressure after release of the occlusion.

3. *The Time Course of the Changes in Blood Pressure After Release of Renal Ischemia.*—Immediately upon releasing the occluding pedicle clamps, there was a passive drop in the blood pressure level, the counterpart of the passive rise in blood pressure observed when the clamps

were applied. When the period of ischemia was prolonged, the blood pressure often fell slowly from the initial passive rise while the clamps were still in place and sometimes no immediate fall was seen on releasing the clamps (Fig. 4). Usually, though not always, there was a brief drop in blood pressure below the level accounted for by passive opening of the renal vascular bed. The duration of this drop was never more than about forty-five seconds before a definite rise in the blood pressure tracing could be recognized. Within three minutes the basal blood pressure level was reached, but the maximum rise was not reached for from six to twelve minutes in different experiments. In the same experiment the peak of the rise in blood pressure was delayed by repetition of the occlusion. In 1 dog, for instance, the peak was reached eight minutes after release of the occluding clamps the first time, while it was delayed to thirty-two minutes after the third occlusion. This latent period was

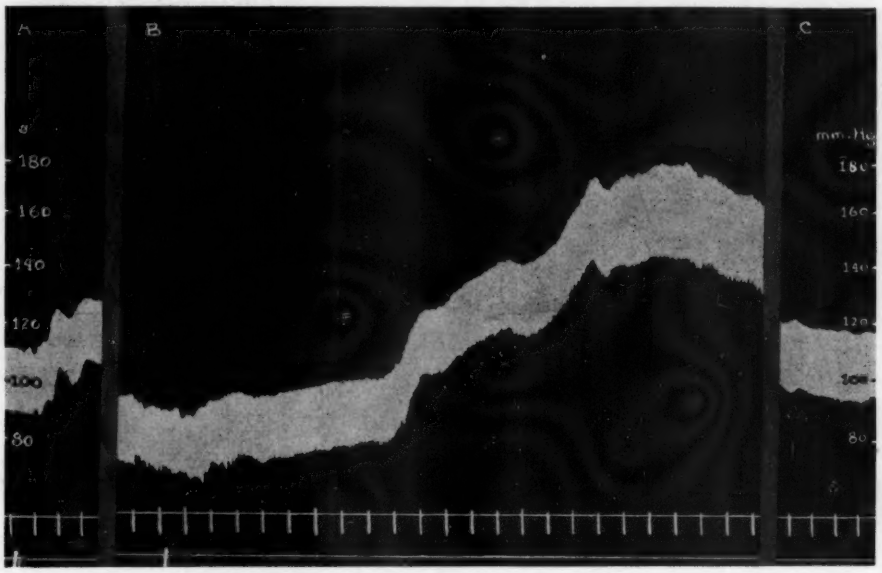

Fig. 4.—Dog 3 (Sept. 20, 1940). Preparation as in Fig. 3. Clamps applied to renal arteries at first signal and released at second signal 105 minutes later. Interval between *A* and *B*, 103 minutes, between *B* and *C*, 22½ minutes. The blood pressure fell slowly while the clamps remained applied. Note that there is no passive fall in blood pressure after release of the clamps.

not related to the duration of occlusion, and it was generally longer in the cat than in the dog. The increased delay in reaching the peak of the pressor response after successive occlusions may be due to injury to which the more delicate renal arteries of the cat are more susceptible than those of the dog.

The average duration of the rise in blood pressure of the cat following release of the occluding clamps was twenty-nine minutes. The maximum and the minimum durations were forty-five and fifteen minutes respectively. In the dog the average duration of hypertension was thirty-three minutes; the maximum was forty minutes and the minimum was

twenty minutes. As observed for the time required to reach the maximum pressor effect, the duration of the hypertension was independent of the duration of the occlusion beyond the ten-minute period. Dicker (1937), in fact, reported pressor effects in the dog lasting only twenty to thirty minutes after releasing renal arteries which had been ligated for twenty-four hours.

4. *Effect of Initial Blood Pressure Upon Development of Hypertension After Release of Renal Ischemia.*—Three of the 5 cats in which no rise of blood pressure was obtained after release of the occluding clamps had initial blood pressures of 60 to 45 mm. of mercury. One of these 3 cats had its spinal cord transected at C7 and both adrenals removed acutely; another had only both adrenals removed; the third had spinal transection at C7 while the adrenals remained intact. Common to all 3 animals was the low initial blood pressure. In none of them was there the passive rise and fall of blood pressure with application and release of the clamps.

Three of the 7 dogs used in these experiments had initial blood pressures under 100 mm. of mercury (92, 72, and 50 respectively). They all gave typical blood pressure responses after releasing the occluding clamps. The dog with the lowest initial blood pressure had had its adrenal glands removed acutely. Nevertheless, when the occluding clamps were released after having been applied for only five and one-half minutes, there was a rise of 25 mm. in blood pressure returning to normal after forty minutes. It appears that, at least in cats, a head of pressure (60 mm. of mercury) is necessary to re-establish the circulation through the previously occluded renal vessels.

5. *Tachyphylaxis.*—Repeated injections of renin have been shown to be progressively less effective in producing the typical rises in blood pressure. This phenomenon was observed first by Tigerstedt and Bergmann (1898) and to it has been applied the term "tachyphylaxis." Repeated occlusions and releases of the renal arteries have shown no evidence of tachyphylaxis in either cat or dog. In no experiment, however, was the occlusion and release repeated more than four times and this may not have been a sufficient number of times to demonstrate the phenomenon.

6. *Effects Upon the Heart.*—In two experiments, an apparent increase in the pulse pressure was observed. In two others, at the height of the blood pressure response, there was a rise in pulse rate to fourteen and eighteen beats per minute above basal respectively. Since these observations were made (a) with the Hürthle manometer which might introduce an artefact in the apparent pulse pressure, and (b) in animals with the sympathetic nerve supply to the heart intact so that the basal rate was usually above 200 per minute and reflex changes were possible, two experiments were done in dogs with direct recording from a mercury manometer, with the heart denervated and with the possibility of adrenal

medullary effects removed. The respiratory rate and amplitude were recorded in these animals by means of a tambour connected with the tracheal cannula through a shunt. There was no evidence of change in pulse pressure, heart rate, or respiratory rate after release of the occluded vascular supply to the kidney. The usual respiratory irregularities due to urethane anesthesia were observed in 1 of the dogs, but these were shown to have no effect on the blood pressure, pulse pressure, or heart rate.

DISCUSSION

In 1905 Katzenstein applied ligatures to the renal pedicles of a curarized dog and released them after thirty-seven minutes of partial occlusion and 177 minutes of complete occlusion. He observed a rise in the arterial blood pressure beginning about three minutes after release of the occlusion, reaching a plateau after eighteen minutes and returning to the initial blood pressure after a half-hour. He attributed this observation to the effects of suspected thrombosis in the renal arterioles rather than to any humoral effect. Indeed, the humoral effects of acute renal ischemia were not recognized until more than three decades later. After the work of Goldblatt and his associates (1933) had demonstrated that chronic partial renal ischemia can cause arterial hypertension through a humoral agency, experiments were reported showing that acute renal ischemia was able to effect a rise in the arterial blood pressure by a similar mechanism (*cf.* Taquini, 1938, 1940). More recently, these observations have been extended by Collins and Hamilton (1940); Prinzmetal, Lewis, and Leo (1940); and Leo, Prinzmetal, and Lewis (1940).

A theory, or "working hypothesis," has been formulated concerning the nature of the humoral mechanism concerned in renal hypertension, (Munoz and associates, 1940; Page, 1940). The ischemic kidney is thought to liberate a substance, *renin,* which, as an enzyme, acts upon a substrate, *hypertensinogen;* or *hypertensin precursor,* present in the pseudoglobulin fraction of blood serum. A new substance, *hypertensin,* is thereby formed which causes arterial hypertension by effecting a diffuse arteriolar constriction. Prolonged incubation of renin and hypertensinogen results in a low yield of hypertensin, presumably due to destruction of this substance by a second enzyme, *hypertensinase,* present in the blood. Hypertensinase is produced by or in the kidney and is destroyed in strongly acid solutions. Hypertensin is called *angiotonin* by Page who has interpreted renin not as an enzyme but as a precursor of angiotonin. A number of properties of renin, however (*cf.* Munoz and co-workers, 1940), favor its enzymatic character.

The experiments reported in this paper indicate a liberation of a multiplicity of substances from the kidney. Some of the experiments showed a preliminary drop in blood pressure below the basal level before

the pressor response became manifest. In 2 cats, in fact, the blood pressure fell precipitously and the animals died (Fig. 5). Other tracings exhibited quick rises in arterial blood pressure superimposed early upon the slow rise characteristic of the renin response (Fig. 3). The rapid adrenaline-like pressor effects may be due to the liberation of hypertensin (or angiotonin) in small amounts. This observation is in agreement with that of Williams and Grossman (1938) who obtained two pressor substances from the ischemic kidney, a heat-stable adrenaline-like substance, and a heat-labile reninlike substance. The rarity with which hypertensin effects were produced in the above experiments supports the evidence recently reported by Prinzmetal, Lewis, and Leo (1940) that the pressor substance liberated after release of complete renal ischemia is renin.

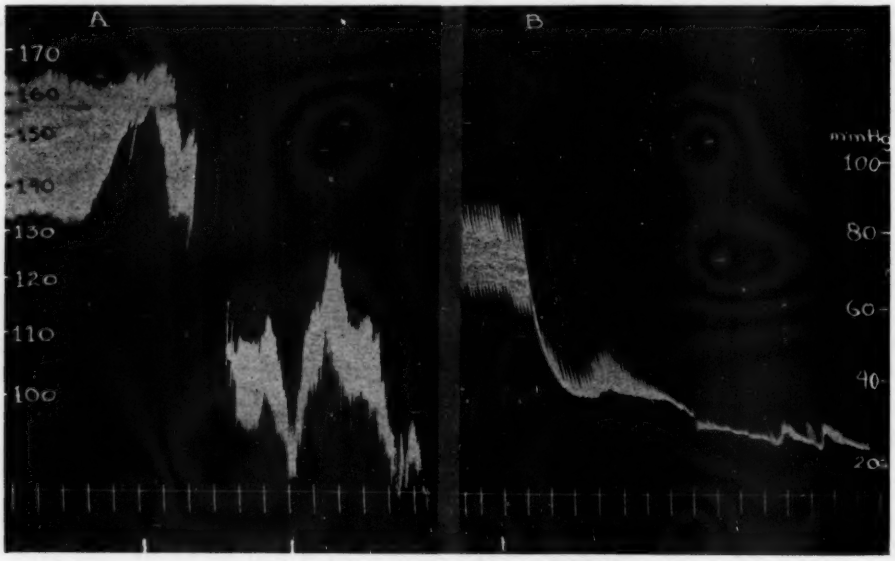

Fig. 5.—*A*. Cat 3. *B*. Cat 6. Urethane (1.5 Gm. per kilogram). Tracings of blood pressure from right carotid artery. Left carotid ligated. Both vagi cut in neck. Calibration of Hürthle manometer as in other figures. Clamps on renal arteries in *A*; on aorta above origin of renal arteries in *B*. Adrenal glands intact in *A*; excluded from circulation in *B*. In *A* (June 22, 1940), clamp removed from right renal vessels at first signal and from left renal vessels at second signal. Note temporary pressor effect upon releasing the second clamp. In *B* (July 11, 1940), the clamp was removed from the aorta at the signal, five hours after application. Heart rate, 226 per minute.

Schroeder and Steele (1940) have reported evidence that the kidneys possess a mechanism whereby they can maintain their blood flow within limits in spite of changes elsewhere in the systemic circulation. If the passive rise and fall of arterial pressure after occlusion and release respectively of the renal arteries is taken as a sign of active blood flow through the kidney (Figs. 2 and 3; Alwens, 1909), the results recorded above indicate that when the systemic arterial blood pressure has fallen below 60 mm. of mercury the blood flow through the kidney is either diminished or abolished. While causing at least a temporary fall in general arterial blood pressure, there is no evidence that sympathectomy or splanchnectomy induces an increase in the blood flow through the kidney

(Smith and associates, 1939). Consequently, the rationale of sympathectomy in arterial hypertension can logically be questioned. As far as the brain, heart, and kidneys are concerned, a reduction in the blood pressure by shunting blood elsewhere than through these organs is the equivalent of bloodletting. To be of therapeutic value, the drop in blood pressure should be effected by some agent which will cause a *generalized* reduction of the peripheral resistance.

The blood pressure tracings obtained following release of complete renal ischemia resemble very closely those obtained by injection of purified or crude renin. The usual absence of immediate hypertensin effects in the records may be due to destruction of this substance by hypertensinase in the kidney. Of especial interest are the facts that only a very short period of total ischemia is necessary for the production of hypertension and that beyond the minimum period of three to ten minutes longer durations do not appreciably affect the degree or duration of the rise in arterial hypertension. This may be explained on the assumption that the substance elaborated by renal ischemia is primarily renin, the reaction of which with hypertensinogen is not stoicheiometric so that quantitatively the limiting reactor is hypertensinogen present preformed in the blood. Within limits, therefore, small amounts of renin liberated during short periods of ischemia would be as effective as larger amounts produced during longer periods.

The mechanism whereby renal ischemia causes the liberation of pressor substances into the blood stream is not understood. Kohlsteadt and Page (1940) have presented evidence that the important result of occlusion of the renal artery for the liberation of pressor substances into the blood stream is the reduction in pulse pressure. They demonstrated that the liberation of renin from the "ischemic" kidney was independent of the mean arterial pressure in the kidney but could be effected by diminution of the pulse pressure even though the mean arterial pressure was maintained at a normal level. The site of liberation or production of the pressor substances is likewise unknown. They may be produced in the convoluted tubules of the kidney. Goormaghtigh (1940) believes that the substances are produced in the "juxtaglomerular apparatus" of the kidney. This consists of cells between the afferent and efferent branches of the glomerular arterioles adjacent to the proximal convoluted tubule. He has interpreted them as modified smooth muscle cells. It is not unlikely that a number of different mechanisms may be involved. Thus Bing and Zucker (1941) and Bing (1941) have reported the production of a potent pressor substance formed by the anaerobic decarboxylation of "dopa" by human and guinea pig renal cortex.

The experiments reported here suggest that the adrenal cortex plays no role in the immediate liberation of pressor substances by the ischemic kidney. The effects of chronic adrenal cortical deficiency in preventing

the pressor response to chronic renal ischemia may be due to a modification of the arteriolar effectors rather than to an interference with the production of pressor substances.

Although many pharmacologic properties of hypertensin are known (*cf.* Munoz and associates, 1940; Page, 1940), the chemical nature of the pressor substances released by ischemic kidneys remains obscure. Further data are required to determine the possible role of hydroxytyramine (Bing, 1941). The mechanism of the hypertension following release of renal ischemia is an increase in the peripheral resistance by arteriolar constriction. The experiments reported above in dogs with denervated hearts and absent adrenal medullae showed no indication of any effect upon the cardiac output or the heart rate.

The presence of an intact normal kidney inhibits the hypertensive effects of ischemia of the other kidney and hastens the return to normal blood pressure following extirpation of the ischemic kidney. The logical implication has been that the normal kidney through the agency of hypertensinase or some similar mechanism counteracts the effects of the pressor substances liberated from the ischemic kidney. Application of these data has resulted in the administration of extracts of normal kidney by Grollman, Williams, and Harrison (1940[a]) and by Page (1940) to hypertensive rats and dogs, with encouraging results. Grollman, Williams, and Harrison (1940[b]) and Page and his co-workers (1941) have treated patients with essential and malignant hypertension with extracts of normal hog kidneys. Although their observations require confirmation, extension, and further control, the results which they have reported are at least suggestive. The experiences of Schroeder (1941) with tyrosinase and those of Wakerlin and Johnson (1941) with the immunologic aspects of hypertension, though only preliminary, are very stimulating.

There is now ample evidence that the kidneys play a major role in the causation of some cases of so-called "essential" hypertension. The physiologic studies of Smith, Rovenstine, Goldring, Chasis, and Ranges (1939) suggest that abnormal tubular function may underlie certain instances of essential hypertension. The significance of such studies is that the group of cases classed necessarily as essential is and will probably continue to grow smaller and smaller. There are at present two goals of first importance in the study of renal hypertension. The first is an understanding of the abnormality responsible for the changes in renal circulation leading to hypertension presumably through the liberation of pressor substances into the circulation. The second is the development of substances which, though not preventing the cause of the disease, can be used to counteract the pressor agents. It is hoped that the technique described above will yield additional information to help reach either or both of the two goals.

CONCLUSIONS

1. A rise in blood pressure followed release of acute renal ischemia in 5 of 10 cats tested and in all of 7 dogs (Figs. 2, 3, and 4).

2. Pressor effects were obtained by total occlusion of the renal arteries for periods as short as three minutes.

3. Beyond the ten-minute period, greater durations of ischemia did not increase the degree or duration of the pressor response upon releasing the occluding clamps.

4. Evidence is presented suggesting that a mean arterial pressure of at least 50 to 60 mm. of mercury is necessary in order to ensure a detectable flow of blood through the kidney as tested in the above experiments.

5. Hypertension was produced by the technique described above without demonstrable effect on the stroke volume or the rate of the denervated heart in animals in which the adrenal medullae had been removed.

6. The experiments reported above are described as a convenient technique for the study of renal hypertension.

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DUODENAL OBSTRUCTION

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DEFINITION OF TERMS

DUODENAL obstruction, in its broadest sense, may be defined as an impediment or hindrance to the forward passage of duodenal contents caused by acquired or congenital conditions. The obstruction may be acute or chronic, complete or incomplete, the characteristic feature being a dilated duodenum.

A survey of the literature concerning duodenal obstruction reveals a lamentable lack of unanimity among authors in respect to the nomenclature. The following are some of the multitudinous terms which have been applied to describe the disease: intermittent duodenal obstruction, duodenal ileus, mesenteric ileus, gastromesenteric ileus, duodenal stasis, stenosis of duodenum, megaduodenum, arteriomesenteric occlusion, dilatation and stasis of the duodenum, chronic compression of the duodenum, etc. It is obvious that these terms may be appropriately used to describe specific or individual types of obstruction; however, when used as all-inclusive titles the result is confusion, and misunderstanding arises.

Frequently, this syndrome is referred to as an ileus. The word ileus is derived from the Latin, meaning to twist. At the present time, as a result of common usage, ileus is applied to designate an obstruction due to paralytic conditions in contradistinction to that due to mechanical causes. To avoid confusion, the term ileus should be restricted to obstruction due to a disturbance in the nervous mechanism.

Mesenteric obstruction (or ileus) is a term which is most commonly applied loosely, inaccurately, and without forethought. Possibly, the reason for this is due to the fact that traction by the mesenteric pedicle is very often the cause of duodenal compression. However, other factors may be the cause, such as embryonal bands, congenital malformations, extrinsic and intrinsic tumors of the duodenum, etc. Hence, the term mesenteric obstruction does not appropriately describe the condition in all cases.

Gastromesenteric ileus, acute dilatation of the stomach, and duodenal obstruction are often used interchangeably and synonymously. This assumption is erroneous because the three conditions may occur independently. Experience has indicated to us that gastric dilatation associated with duodenal obstruction was conspicuous by its absence. We

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believe that gastric dilatation and duodenal obstruction are two distinct clinical entities. For the sake of clarity the two conditions should be disassociated from each other.

Duodenal obstruction as a clinical entity is not readily understood nor generally appreciated. It is obvious that one of the reasons for this apathetic state arises from the incongruous and somewhat bounteous terms of definition. The term duodenal obstruction is self-explanatory, therefore readily understood. It is all inclusive and describes the syndrome in every case regardless of the etiological factor or its pathogenesis. Therefore we cannot be far amiss by strongly advocating the use of duodenal obstruction as the title for describing the disease, regardless of the type, in future publications on the subject.

ETIOLOGICAL CLASSIFICATION

Duodenal obstruction may occur at any age, afflicting male and female alike, possibly the female more often. Almost every factor in the causation of the disease has been reported. A classification of duodenal obstruction based upon etiological factors would be of material help toward a more complete understanding of the subject. Furthermore, an etiological classification has the merit of focusing attention to the fact that duodenal obstruction, as a clinical entity, is caused not only by arteriomesenteric compression, but by numerous other factors which are by far the more common causes of obstruction. These factors may be classified in two general groups: (1) those which are basically of congenital origin, and (2) those which are acquired. It is obvious that the two groups overlap in many instances. Very often the predisposing factors are acquired; whereas, the basic factor in the pathogenesis of the obstruction is of congenital origin. For instance, arteriomesenteric obstruction is in reality an accentuation of a normal condition, hence basically congenital, while the predisposing factors are usually acquired. This type of obstruction should be placed in the congenital group with the realization that it is not truly a congenital condition. Bearing these equivocations in mind, the following classification is suggested:

I. Congenital duodenal obstruction
   A. Arteriomesenteric (compression of duodenum by mesenteric pedicle). This type is influenced by the following predisposing factors:
      1. Ptosis of small intestine due to loss of mesenteric fat
      2. Abdominal relaxation following pregnancy and debilitating diseases
      3. Ptosis of large bowel
      4. Lordosis of lumbar spine
   B. Mesocolic. In this type of obstruction the duodenum becomes compressed by the mesocolic root alone. The condition is often associated with prolapsed hepatic flexure of the colon.
   C. Arteriomesocolic. In this type the duodenum is compressed by the mesocolic root and the middle colic vessels. It is associated with a mobile cecum and a prolapsed ascending colon and hepatic flexure.

D. Extrinsic duodenal atresia (complete gap in duodenal continuity). The partition may be due to:
   1. Arrested development
   2. Vascular changes
   3. Inflammatory effects

E. Extrinsic duodenal occlusion
   1. Anomalous mesenteric vessels occluding duodenum (Buchanan)
   2. Anomalous annular pancreas
   3. Abnormal embryonal peritoneal bands
      a. Hepaticoduodenal (Fig. 2*A*)
      b. Hepaticoduodenocolic (Fig. 2*E*)
      c. Duodenoduodenal (agglutination of first upper half to second portion of duodenum). (Fig. 2*D*)
      d. Duodenorenal
      e. Jejunomesocolic (Mayo's band; also present Case 3)
   4. Contraction of ligament of Treitz, drawing duodenojejunal angle upward
   5. Faulty rotation of duodenum may produce complete or incomplete occlusion
   6. Intraperitoneal mobile duodenum
      a. With omentum and ascending colon attached to duodenum and jejunum (Bargen and Walter's case)
      b. With complete interruption of duodenum (Kellogg's case)

II. Acquired duodenal obstruction

A. Inflammatory adhesions or bands
   1. Due to infection of gall bladder
   2. Essential periduodenitis of Duval
   3. Hepaticoduodenocolic bands as result of gall bladder, colonic, or gastric disease.
   4. Fixation by adhesions of transverse colon into true pelvis associated with sinking of the small intestine (present Case 2)
   5. Contracting adhesions from peptic ulcer or pancreatitis

B. Extrinsic compression
   1. Enlarged inflammatory lymph glands
   2. Lymphatic enlargement from Hodgkin's disease (present Case 5)
   3. Aneurysm of abdominal aorta (present Case 6)
   4. Kinking and angulation of duodenum following gastric operations
   5. Secondary compression of duodenum by dilated stomach (Dragstedt)

C. Intrinsic occlusion
   1. Gall bladder stones and foreign bodies
   2. Carcinoma of duodenum
   3. Intussusception due to pyloric or duodenal polyp (Kellogg)

D. Extraduodenal
   1. Jejunal dilatation due to compression at pelvic brim when small intestine is tightly wedged into pelvis (Kellogg)
   2. Jejunomesocolic inflammatory bands attaching jejunum to mesocolon

PATHOLOGIC ANATOMY

The duodenum is from 10 to 12 inches long and extends from the pylorus to the duodenojejunal flexure. It varies from a U- to a C-shape, with the concavity of its curvature directed upward and to the left. The duodenum may be divided into four parts: (1) superior horizontal, (2) descending, (3) inferior horizontal, and (4) ascending or terminal.

The first part measures about 2 inches in length and is the direct continuation of the pylorus. It is completely surrounded by peritoneum and is rather movable. Its course is backward, to the right, and slightly upward, terminating downward into the descending portion. It forms the lower border of the foramen of Winslow and is in contact with the under surface of the left lobe of the liver and the neck of the gall bladder.

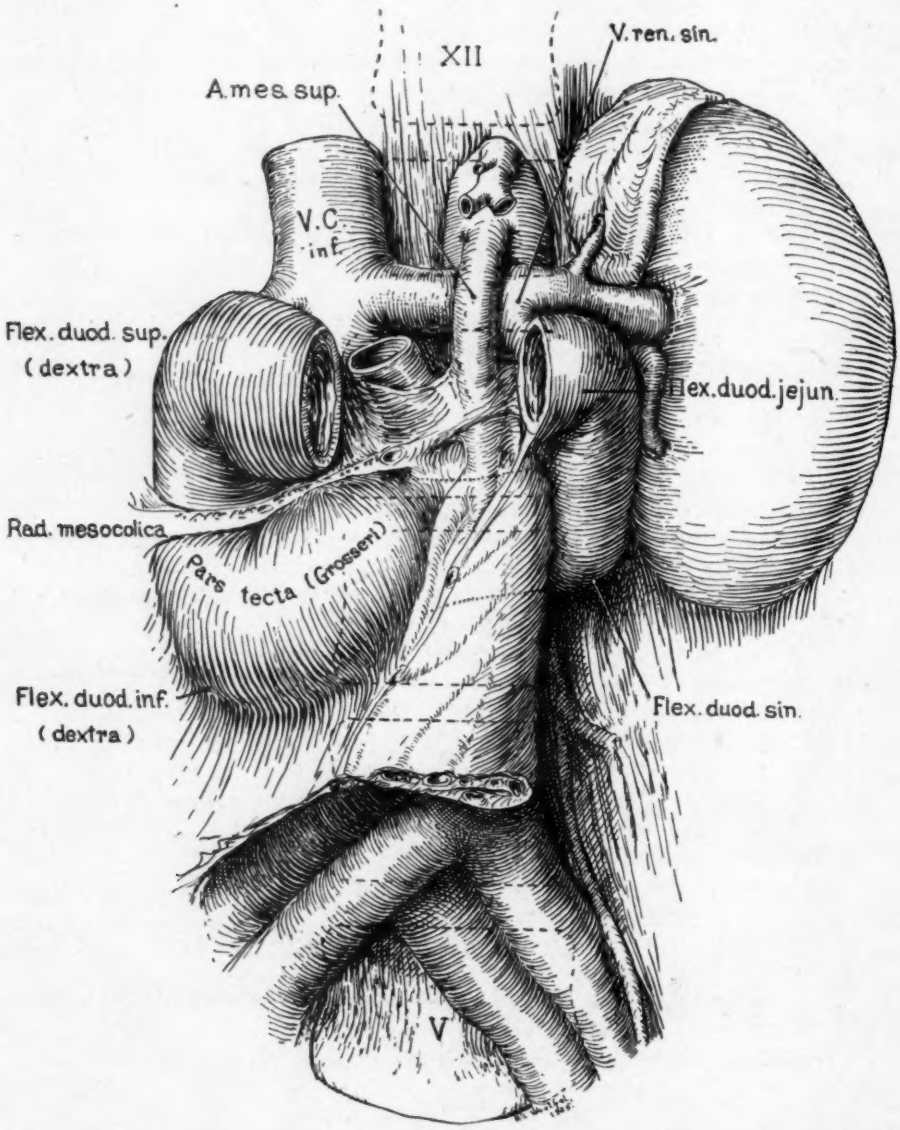

Fig. 1.—Drawing showing the topographical relationship of the duodenum, the left renal vein, and the superior mesenteric artery. (Courtesy of Dr. Béla Halpert.)

The descending portion of the duodenum is from 3 to 4 inches long. It descends along the vertebral bodies to the level of the middle of the

third lumbar vertebra, where it turns to the left and becomes continuous with the third part. It is covered by peritoneum on its anterior surface except at its middle portion where it is crossed by the root of the mesocolon. Fig. 1, taken after Halpert, is a schematic drawing illustrating the relationships of the duodenum. Note that the root of the mesocolon is shown as dividing the duodenum into an upper, supramesocolic, and a lower, inframesocolic part. This relationship is of definite clinical value as the mesocolic root may be a factor in compressing the duodenum. This is not generally appreciated nor readily understood. Bloodgood (1912) was of the opinion that this type of duodenal obstruction was due to traction on the mesenteric pedicle as a result of a dilated cecum displaced into the pelvis, and that tension on the mesentery of the small bowel could not occur unless the last portion of the ileum had an unusually short mesentery. According to Halpert (1926), "the last portion of the ileum always has a very short mesentery, or better, it never has one of any considerable length unless the cecum is movable. A displaced cecum can hardly exert sufficient tension on the mesentery of the small intestine to produce an obstruction of the duodenum, but it may do so on the mesocolon, provided that the right half of the colon has a mesocolon and is freely movable. The occlusion of this type is caused by the mesocolon and not by the mesenterium, and is therefore rather an 'arteriomesocolic' than an arteriomesenteric occlusion." He further states that, "traction on the superior mesenteric artery is also present and is exerted by the ileocolic, right colic, and middle colic arteries and not by the jejunal arteries as occurs in arteriomesenteric obstruction." In conformity with the desire to clarify the nomenclature, the term mesocolic obstruction should be applied when the compression is the result of traction by the mesocolon alone and the term arteriomesocolic when the obstruction is due to a combined traction by the mesocolon and the vessels.

Having a knowledge of the relationship of the right kidney, hepatic flexure of the colon, and the gall bladder to the first and second portions of the duodenum makes it rather easy to understand how malformations or ptosis of the kidney and colon and bands of adhesions may drag upon and distort the duodenum to produce varying degrees of obstruction. Fig. 2 illustrates various deformities of the duodenum that may result from embryonal or inflammatory bands.

The inferior horizontal part of the duodenum crosses the abdominal wall at the level of the third lumbar vertebra, from the right to the left. Its direction is slightly upward, terminating at the left of the upper part of the third lumbar vertebra. At its termination it is crossed anteriorly by the root of the mesentery of the small bowel (Fig. 1). The superior mesenteric artery, contained within the mesenteric root, springs from the abdominal aorta about ½ inch below the origin of the celiac artery

opposite the first lumbar vertebra. It proceeds downward and forward anteriorly to the left renal vein and emerges from under the head of the pancreas to enter the mesentery of the small intestine. The artery accompanied by the vein continues downward, curving obliquely toward the right iliac fossa to terminate by anastomosing with one of its branches, the ileocolic artery. It is a significant anatomical fact that the superior mesenteric artery does not cross the duodenum until after it has entered the root of the mesentery. This is stressed by Halpert who states that "although the branches of the superior mesenteric artery lie between the leaves of the mesenteric fold causing the obstruction, the latter is not produced by the trunk of this vessel, nor is its site at the point where the artery leaves the aorta." If traction is applied directly on the superior mesenteric artery, the left renal vein may be compressed which may cause circulatory changes in the left kidney.

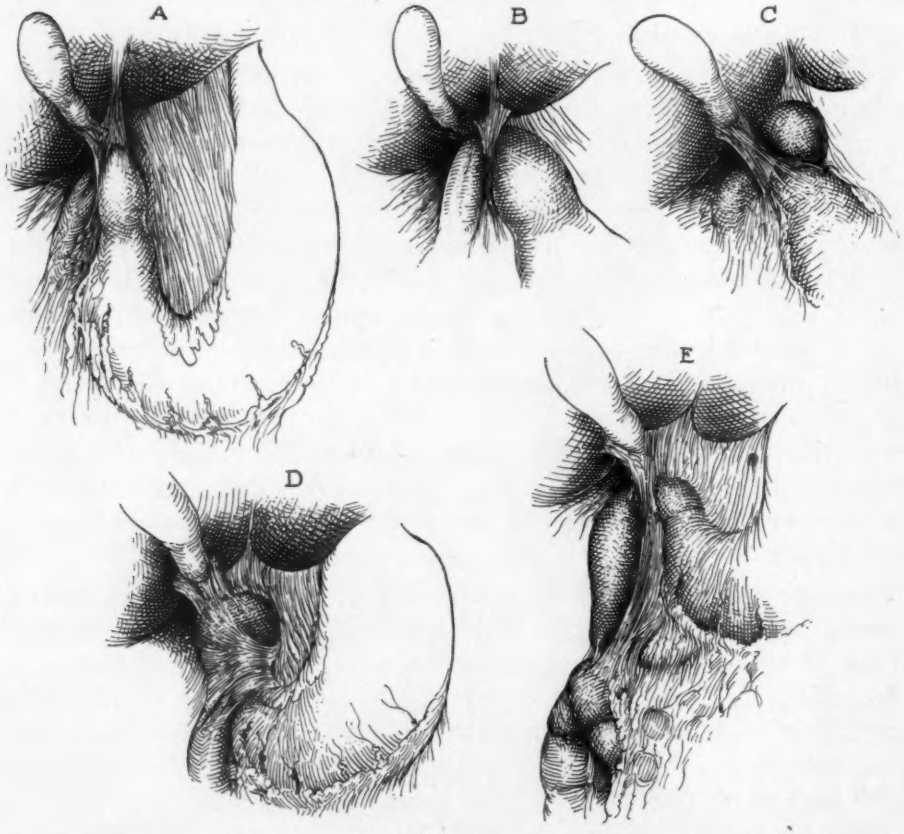

Fig. 2.—Drawing showing various deformities of the duodenum produced by embryonal and inflammatory bands: *A.* Hepaticoduodenal. *B.* Hepaticoduodenomesocolic. *C.* Gastroduodenobiliary. *D.* Duodenoduodenal. *E.* Hepaticoduodenocolic.

In order to understand properly the pathogenesis of arteriomesenteric obstruction, one should visualize the duodenum as being located within a nutcracker with the mesenteric pedicle forming the anterior flexible half, and the aorta and spine the fixed posterior portion. Normally the

duodenum is slightly compressed, and various investigators have demonstrated a groove on its anterior surface caused by the mesenteric pedicle. According to Kellogg, the posterior surface of the duodenum also has a groove which is due to pressure of the spine alone or spine and aorta together. Hence the pathogenesis of duodenal obstruction is an exaggeration of a normal condition (Fig. 3*A*). Since the duodenum is relatively immobilized and the spine is unyielding, the only structure which can constrict it is the mesenteric pedicle. This occurs when a downward and backward traction is exerted on the pedicle with sufficient drag to narrow the spinomesenteric angle. Thus any condition which diminishes the space between the spine and the pedicle will do so at the expense of duodenal patency. The process is further aggravated when the spine is thrown forward, as occurs in increased lordosis of the lumbar spine. This was emphasized by Schnitzler and Vanderhoof.

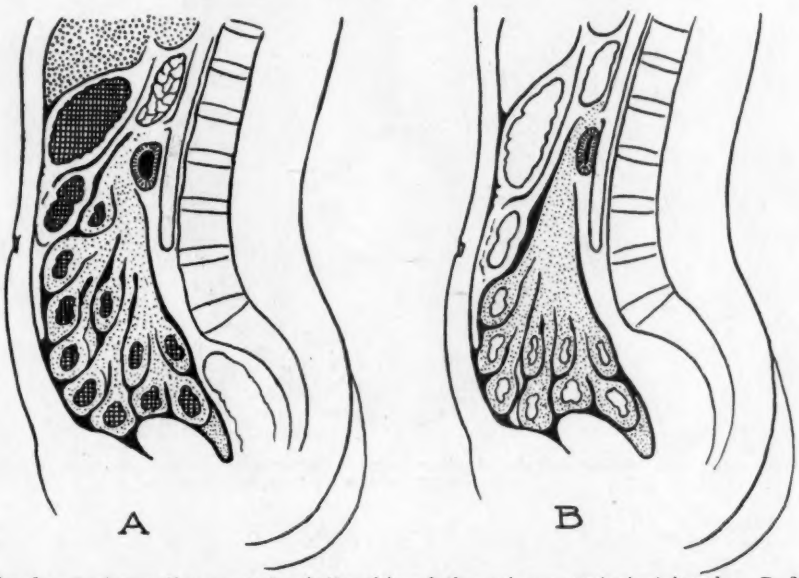

Fig. 3.—*A* shows the normal relationship of the spinomesenteric triangle. *B*. Narrowing of the triangle with compression of the duodenum as a result of loss of mesenteric fat.

There are numerous predisposing factors. We have already alluded to the ptosed colon and the drag upon the mesenteric pedicle by the vessels supplying the right half of the colon. Fig. 4 graphically illustrates duodenal dilatation resulting from traction by the middle colic artery, following ptosis of the right half of the colon and the hepatic flexure. Normally the small intestine is retained within the abdomen proper by the mesenteric fat; however, when there is an appreciable loss of this fat, the intestine loses its support and sinks into the lower abdomen and even into the true pelvis (Fig. 3*B*). As a consequence there is a downward and backward traction on the mesenteric pedicle, thus narrowing the spinomesenteric angle, with the result that the duodenum becomes

compressed. Similarly, since the small intestine is suspended in a vertical position from the posterior body wall, a relaxation of the abdominal wall facilitates the prolapse of the small intestine. Therefore, frequent pregnancies, or any factor which augments abdominal relaxation, aggravates the condition. This is further aggravated in the female because all the diameters of the pelvis are increased. The greater incidence of visceroptosis in the female is probably due to this factor.

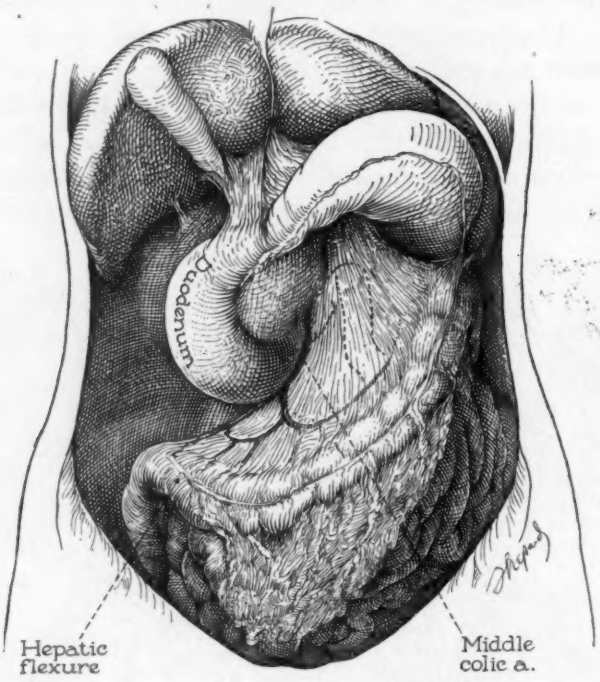

Fig. 4.—Duodenal dilatation due to traction by the middle colic artery as a result of ptosis of the ascending colon and hepatic flexure.

While traction on the mesenteric pedicle is the most common cause of compression, the terminal duodenum may also become constricted by the middle colic artery as a result of a prolapsed transverse colon. This occurred in one of the cases herein reported. The middle colic artery arises from the front of the superior mesenteric artery just before the latter enters the root of the mesentery of the small intestine. In our case, the transverse colon was firmly adherent by adhesions to the true pelvis, dragging the middle colic artery vertically downward and backward in the same plane as the mesenteric pedicle of the small intestine. The duodenum was found greatly distended, and we believe that its compression was due to the traction by the middle colic artery, and not by the mesenteric pedicle. Nevertheless, it is possible that the middle colic artery may have arisen from the superior mesenteric after the latter artery crossed the duodenum. In such contingency the compression

would be due to traction on the mesenteric pedicle by the middle colic artery. This is only of academic interest, because in either exigency the treatment is the same.

There is considerable controversy concerning the pathogenesis of acute gastric dilatation. Two theories have been proposed: (1) that the dilatation is primarily a reflex nervous disturbance; (2) that dilatation of the stomach is associated with, or is secondary to, arteriomesenteric obstruction. Kellogg (1935) recognized the possibility of acute gastric dilatation, but believed that in the majority of instances mesen-

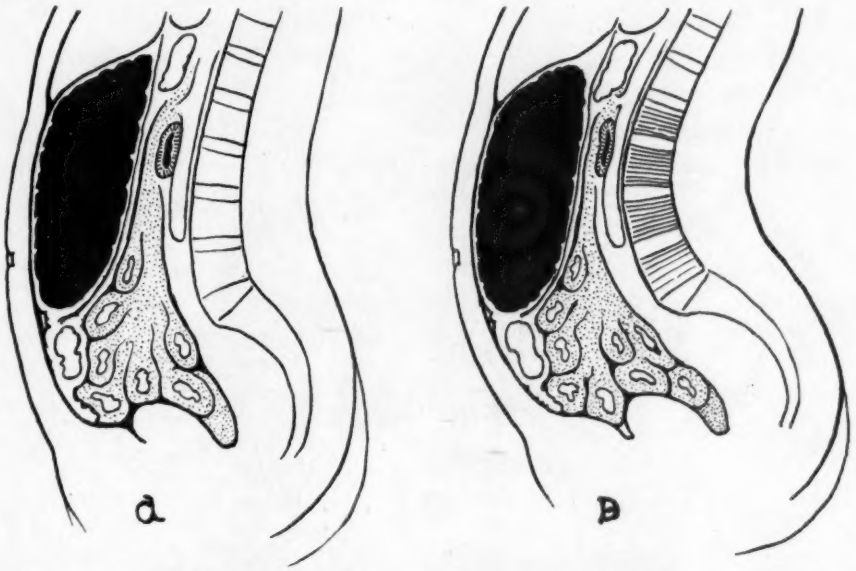

Fig. 5.—*A*. illustrates how dilatation of the stomach forces the small intestines into the pelvis, produces a downward and backward traction on the mesentery, and *B* a secondary duodenal compression (after Dragstedt and co-workers).

teric obstruction was also found. He thought that the essential pathology was compression of the third part of the duodenum by the mesenteric pedicle. He stated that gastric dilatation may also be produced by kinks at the superior and duodenal-jejunal angles, and occasionally by compression of the jejunum at the pelvic brim when the small intestines are tightly wedged into the pelvis. On the other hand, Dragstedt, Montgomery, Ellis, and Matthews, in an excellent study of the subject concluded that gastric dilatation following operation was due to a reflex inhibition of the peripheral gastric motor mechanism through impulses reaching the stomach by way of the vagi and splanchnics. They believed that an enlarged duodenum, if present, was secondary, and was caused either by a direct pressure of the dilated stomach on the transverse duodenum, or by a secondary arteriomesenteric compression brought about by the downward pressure of the dilated stomach which forced the intestine into the pelvis (Fig. 5).

While not wishing to become involved in this controversy, nevertheless, it is our opinion that the proponents of these theories are at cross purposes. It is universally agreed that acute gastric dilatation is most frequently seen as a postoperative complication and seldom as a consequence of arteriomesenteric obstruction. In none of the cases of primary acute duodenal obstruction did we observe a grossly dilated stomach. This is also the experience of others. This significant observation must be taken into consideration when discussing the pathogenesis of acute gastric dilatation. Since gastric dilatation is an uncommon sequela of arteriomesenteric obstruction, it is logical to conclude

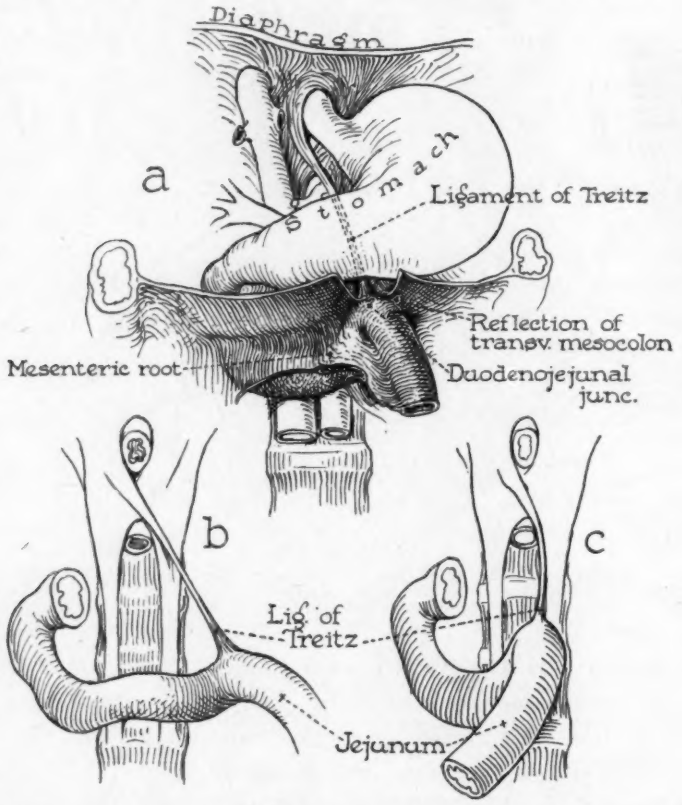

Fig. 6.—*A.* Schematic representation of the duodenum and its relationship. *B.* Elongated ligament of Treitz. *C.* Short ligament which draws the duodenojejunal flexure rather high and to the left, thus rendering the flexure more acute.

that its causative factor must be looked for elsewhere, possibly in the stomach as suggested by Dragstedt and his co-workers. On the other hand, it must be conceded that when the duodenum is coincidentally enlarged with the stomach the phenomenon is most likely and primarily of arteriomesenteric origin, and not secondary to the pressure of a dilated stomach. Thus there are two distinct clinical entities: (1) postoperative acute gastric dilatation due to a disturbance in the gastric nervous innervation and not accompanied by a duodenal dilatation,

the most common type; (2) gastromesenteric obstruction, an uncommon postoperative complication and its causative factor is primarily in the duodenum. If these terms are properly applied, a great deal of confusion and misunderstanding will be obviated.

Duodenal obstruction not infrequently occurs as a result of an acute angulation of the duodenojejunal flexure. Its pathogenesis is based upon a disturbance of the normal relationship of the duodenum and the ligament of Treitz. When the terminal duodenum reaches the left side of the first or second lumbar vertebra, it turns abruptly forward, downward, to the left, and passes into the jejunum. This bend, known as the duodenojejunal flexure, is fixed by a thin band of unstriped muscle called the ligament of Treitz. The latter is attached to the left crus of the diaphragm, and is continuous with the duodenal musculature. Its relative length determines the position of the duodenojejunal flexure. If short, the flexure is placed rather high and to the left, thus rendering the flexure more acute (Fig. 6*C*). The acuteness of the angulation may be accentuated by a gastrojejunostomy, especially when the patient is in Fowler's or semisitting position. For this reason the surgeon should examine the duodenojejunal flexure in all cases when a posterior gastrojejunostomy is contemplated. If found acutely angulated, the ligament should be divided and its end ligated.

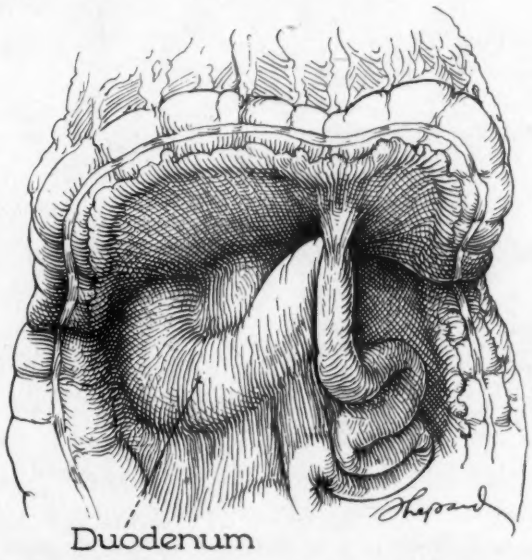

Fig. 7.—Mayo's band. The first portion of the jejunum is fixed to the inferior surface of the mesocolon, thus acutely angulating the duodenojejunal flexure by pulling the jejunum to the right of the body.

Duodenal obstruction may also result from an abnormal attachment of the first loop of jejunum to either the transverse colon or mesocolon. In 1908 Mayo described the attachment of the first loop of jejunum to the transverse mesocolon by bands of adhesions. As illustrated in Fig. 7,

this band unites the inferior surface of the mesocolon to the anterior surface (right side) of the jejunum, thus pulling the jejunum to the right side and acutely angulating the duodenal jejunal angle. A very unusual abnormality of the first loop of jejunum was observed in Case 3. As illustrated in Fig. 8, about 3 inches of the jejunum was firmly attached to the transverse mesocolon by a peritoneal band. Kellogg described a case of duodenal obstruction due to compression of the jejunum at the pelvic brim as a result of the small intestine's being tightly wedged into the pelvis.

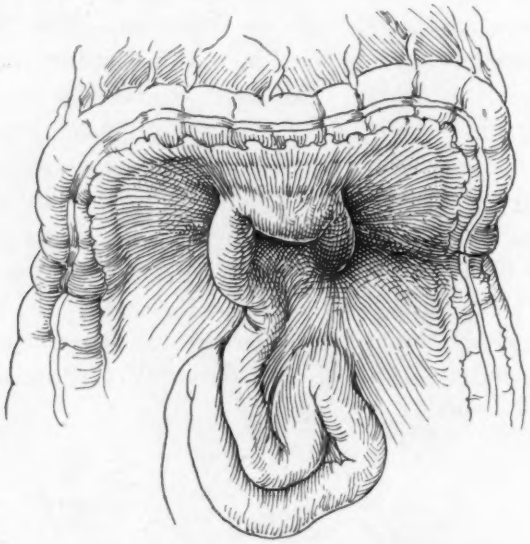

Fig. 8.—About 3 inches of the jejunum are attached to the transverse mesocolon by an embryonal peritoneal band (Case 3).

DIAGNOSIS

The diagnosis of duodenal obstruction may be easily arrived at in some cases, while in others it may not be so obvious. The first requirement for a diagnosis is a thorough knowledge and familiarity with the subject, and the utilization of this knowledge in the differential diagnosis of all obscure upper abdominal diseases. The duodenum has been called the silent portion of the gastrointestinal tract, however, it will speak loudly if attention is paid to it. No single symptom or combination of symptoms and physical findings is pathognomic. However, when these symptoms and findings are analyzed in conjunction with the history of the case, and supplemented with roentgen studies, they assume definite characteristics indicative of duodenal obstruction.

The history of chronic duodenal obstruction reveals that the age group is in the third decade, and that it occurs more often in the female than in the male (ratio variably given as 3:1). These patients are the visceroptotic type; asthenic, undernourished, thin individuals with

scaphoid abdomens. A great majority of them have had previous medical treatment for "stomach trouble," peptic ulcer, gall bladder disease, chronic appendicitis, dyspepsia, "nervous stomach," "vagotonia," neurasthenia, or other chronic abdominal ailments. Many will give a history of having had one or more laparotomies, which not only failed to relieve them but very often aggravated the original symptoms. The physician should be on the alert and investigate the duodenum when a patient gives a history of being treated for neurasthenia, gastric neurosis, or dyspepsia. It is our belief that the underlying cause of neurasthenia in some cases is due to an obscure disturbance of one of the body systems, such as the reproductive, endocrine, genitourinary, gastric, etc. If a neurasthenic patient presents gastric symptoms, it seems logical to us that duodenal pathology should be ruled out.

Patients with chronic duodenal obstruction involving the first or second portion of the duodenum may be well developed and do not present the physical characteristics of the asthenic type. Their symptoms usually are wrongly diagnosed as peptic ulcer or chronic gall bladder disease. Very often it is difficult to make a differential diagnosis as the symptoms of chronic obstruction affecting the first and second portion of the duodenum are similar to these conditions. However, two important facts stand out: (1) medical treatment for peptic ulcer or for the gall bladder disease fails to relieve the symptoms, and (2) roentgen studies invariably reveal a duodenal deformity.

A host of symptoms descriptive of duodenal obstruction have been enumerated by various writers. The following is a more or less comprehensive list: vomiting, nausea, bilious attacks, migraine headache, constipation, loss of weight, eructation, epigastric pain, regurgitation, borborygmus, dragging sensation, etc. One can readily see that these symptoms taken singly or collectively are suggestive of any number of abdominal diseases, and not conclusive of any. However, when analyzed in relation to the duration of the illness, onset and course, and correlated with physical and x-ray findings, they assume certain features characteristic of duodenal obstruction, and become distinguishable from other abdominal conditions.

The history reveals that in chronic duodenal obstruction the illness is of long duration. Many patients will date back their complaints since childhood. The diagnosis of chronic duodenal obstruction in one of our patients (Case 3), who was referred to us with a diagnosis of perforating and bleeding ulcer, was made because the patient stated that he had had gastric distress since he was 6 years old. This was the only clue which, coupled with subsequent roentgen findings, indubitably revealed the cause for the long-drawn-out history of gastric distress. The operative findings revealed a duodenal obstruction due to fixation of the first loop of jejunum to the transverse mesocolon in addition to the ulcer complications.

Another characteristic feature of the chronic type is the intermittent recurrent attacks. In some individuals these attacks may be in the nature of "gastric disturbances," such as constipation, nausea, headache, and "bilious attacks," while in others they may be ushered in with nausea, vomiting, epigastric pain, and other symptoms indicative of a high intestinal obstruction. In some individuals the attacks may not be particularly severe until early adult life. In such cases the acute attack is probably brought on as a result of abdominal relaxation following frequent pregnancies, or loss of mesenteric fat following a debilitating disease. It should be stressed at this time that acute duodenal obstruction ushered in without a history of previous attacks is usually due to occlusion of the duodenum by extrinsic or intrinsic tumor.

Of the symptoms enumerated, vomiting is the most characteristic. It is generally intermittent and the vomitus contains enormous quantities of bile. When the obstruction is complete, the emesis is abundant, continuous, and occurs soon after a meal is eaten. The attack may last twenty-four hours or longer depending upon the degree of obstruction. In one of our cases (Case 1) the patient vomited for a period of nine days, and was relieved only after a duodenojejunostomy was performed. At times, vomiting will be relieved by assuming the knee-chest position, or by lying on the abdomen or the right side. This is a significant factor to elicit in the history since it is only in duodenal obstruction that posture will relieve the patient of vomiting. In Case 2, the patient stopped vomiting while resting in bed with the foot elevated 18 inches. This was used as a therapeutic test. Subsequent x-ray examination confirmed the diagnosis. This test is not always positive as elevation of the foot of the bed may not always relieve the compression of the duodenum.

Epigastric pain is associated with vomiting. It varies from a mild discomfort to a sharp colicky pain. The patient is relieved or the pain subsides after vomiting. The pain in duodenal obstruction is probably due to the distended duodenum and to the unyielding spastic pylorus. When the pylorus yields, the duodenal contents empty into the stomach and the patient vomits. Thus relief of pain which follows is possibly the result of pyloric relaxation and relief of intraduodenal pressure. The process is a vicious circle as the pain will recur with subsequent accumulation of secretion in the duodenum. In some cases vomiting may not be a prominent feature; however, examination of gastric contents will reveal large quantities of bile.

X-RAY EXAMINATION

Careful roentgen studies will confirm the diagnosis in practically every case. It should be noted, however, that if these studies are made in between the acute attacks, when the patient is free from symptoms, the roentgen observations may be negative. Roentgen observations were

first reported by Jordan in 1911, who described and showed by x-ray plates the findings of duodenal obstruction. These findings were verified by Lane. Jewett, quoted by Lichty, insisted that certain essential points are necessary to establish the diagnosis. He said: "The essential points then are dilatation of the duodenum, writhing of the duodenum, waves of reverse peristalsis, puddling at the duodenal junction. There is usually a low descending loop in the duodenum and a high point of fixation of the duodenojejunal angle which can be demonstrated by lifting of the stomach. There is often a six-hour gastric stasis, and the duodenal cap is not infrequently dilated along with the rest of the duodenum. The diagnosis, however, is made largely on the fluoroscopic findings."

Kellogg and Kellogg, in 1927, noted that changes in the duodenum follow one of four types:

1. Asthenic duodenum (symptoms latent or toxic). Roentgen examination may show delay or puddling in the duodenum, with sluggish peristalsis and slight or no dilatation.

2. Duodenal obstruction, with incompetent pylorus. Bile regurgitates easily into the stomach. Dilatation is usually moderate or absent. Roentgen-ray examination is negative or shows reverse peristalsis.

3. Obstruction, with hypertrophy (the writhing duodenum). The duodenum is elongated and its walls are thickened. Under the fluoroscope it is seen to labor over its contents.

4. Dilated duodenum. The area of duodenal tympany is increased; succussion is present. Pain occurs, either steady and dull or cramplike. This variety is most readily demonstrated by the roentgenologist.

Shattuck and Imboden have made the following observations:

1. Bands about the first and second portion of the duodenum may show the duodenum markedly contracted in size in comparison with the size of the stomach, or it may be larger than normal. The duodenum may be deformed, as in ulcer, but the deformity is not constant and varies from time to time in various positions.

2. The upper part of the descending limb may be fixed, and the part adjacent to the liver may have a flattened appearance, thus obliterating the normal curvature of the duodenum.

3. A commonly observed phenomena is a fixation of the dependent limb of the duodenum to the liver at a certain point, producing a definite angulation.

4. Obstruction at the ligament of Treitz shows the angle is shifted to the right of its normal position. The dependent duodenum is usually enlarged, especially in its transverse diameter, and the valvulae conniventes are frequently absent.

To summarize, the findings and technique of fluoroscopic examination are: The examination is made while the patient is standing. After the stomach has been examined, it is pushed upward and to the left by the examiner's hand, thus gaining an unobstructed view of the duodenum.

Barium will be seen to enter the duodenum rather rapidly at first; however, as soon as it reaches the lumbar vertebrae, it stops. The duodenum becomes filled and is seen to enlarge. Soon the barium from the stomach stops flowing into the duodenum, and instead, as a result of an active antiperistalsis, there is regurgitation of the duodenal contents into the stomach. The duodenum may appear to be contorted or writhing, and the contents may be seen to sway back and forth in churning movements. A five-hour plate will invariably reveal duodenal and gastric residue and a dilated duodenum.

Disappearance of these findings by Hayes' maneuver is confirmatory. The Hayes' maneuver is as follows: Pressure is made by the hand over the abdomen just below the umbilicus. The mass of intestine is pushed upward, backward, and to the left, thus relieving the downward and backward traction on the mesenteric pedicle. In about thirty seconds the duodenojejunal angle is opened and the duodenal contents are seen to pass into the jejunum. The descending portion of the duodenum may be visualized in the lateral view.

TREATMENT

The treatment of duodenal obstruction depends to a great extent upon the underlying causative factor. The treatment for the visceroptotic type and for the chronic form of duodenal obstruction is preferably medical. The objective is to increase the fat content of the mesentery in order to elevate the small intestine upward and forward, thereby relieving the backward and downward traction on the duodenum by the mesenteric pedicle. This can be accomplished by postural rest in bed, high caloric fat diet, and abdominal exercises. Having the patient rest in bed, the foot of which is elevated 12 to 18 inches, permits the small intestine to migrate into its normal position. The pressure on the duodenum is materially relieved by having the patient lie on the abdomen as much of the time as possible, especially immediately after each meal (at least twenty minutes). The abdominal muscles are strengthened by abdominal massage, setting-up exercises, and alternate raising of the legs at right angles with the body in the prone position. In the beginning these exercises must be done with moderation, and at no time must they tire the patient. At the same time the patient is placed on a nourishing diet. During the first few days the food intake should contain about 1,800 calories, and later should be increased to a minimum of 3,000 calories. The major portion of the foods should contain high caloric values in fats and carbohydrates, such as vegetables, fruits, cereals, fish, milk, cream, farinaceous puddings, butter, etc. The food should be thoroughly cooked, and small frequent feedings are preferable to the usual three meals a day.

The majority of these patients are constipated, hence every effort should be directed to control normal bowel movements. Strong laxatives

or purgatives should be avoided as they only aggravate the condition. Judicious use of mineral oil or milk of magnesia has been found to be serviceable in our experience. As long as the patient is resting in bed 1 tablespoonful of milk of magnesia is given three times a day until the number of bowel movements are abnormally increased, when the amount of magnesia is decreased to produce a normal desired effect.

Postural rest in bed, judicious exercises, and intelligent use of a high-calorie diet prolonged for a period of months will bring about relief in the great majority of patients. If satisfactory results are not obtained, surgical intervention is indicated. The following criteria may be used to decide the question of operation: (1) failure of medical treatment to relieve the symptoms after a prolonged fair trial; (2) inability of the patient to gain weight after three months of postural and medical management; (3) duodenal retention as shown by a five-hour x-ray plate; (4) persistency of vomiting during medical treatment; and (5) recurrent attacks of vomiting.

For the mesenteric type of obstruction the operation of choice is a duodenojejunostomy. This is the only procedure which adequately and thoroughly drains the obstructed duodenum. Some authors have suggested a gastrojejunostomy; however, it must be recognized that this operation does not adequately drain the obstructed duodenum. It relieves the patient temporarily by short-circuiting the gastric contents, but the duodenal contents are not emptied, and as a result, the patient may continue to complain of the original symptoms. A gastrojejunostomy may even aggravate the condition by increasing the duodenojejunal angle, thus complicating the mesenteric obstruction. We agree with Wolfer (1927) that suspension of the ptosed viscera is uniformly unsuccessful for the cure of arteriomesenteric obstruction.

When the cause of the obstruction is an inflammatory or embryonal band, simple division of the band is the procedure of choice. Denuded surfaces must be peritonized by either an omental graft or by suturing, else the condition is apt to recur. Gastrojejunostomy or better, gastroduodenostomy is the logical procedure in those cases with massive adhesions involving the first portion of the duodenum.

Colopexy, after the technique of Waugh, or colofixation to the anterior abdominal wall is the operation of choice for the mesocolic and arteriomesocolic obstruction. For the arteriomesocolic type, a duodenojejunostomy is a logical supplemental procedure, as colopexy or colofixation alone may not completely relieve the compression. Right colectomy as suggested and performed by Bloodgood is too formidable and should be replaced by a more conservative and less dangerous procedure.

The treatment of carcinoma of the duodenum, when the growth is removable, is resection with an end-to-end anastomosis to re-establish the lumen continuity. If the growth is fixed or invasive, or if metastases are present, a duodenojejunostomy is indicated.

CASE REPORTS

CASE 1.—Sister M. C., aged 31 years, was admitted to the St. Mary of Nazareth Hospital on June 27, 1937. The chief complaints were vomiting for one month, epigastric pain of two months' duration, nausea, and loss of 13 pounds in weight within the past two months. The pain was localized in the upper right quadrant. At the onset, about two months before, it was mild and associated with nausea; however, within five weeks it had become more severe, nausea increased in proportion, and soon the patient vomited a green-colored fluid which brought about relief of pain. The attacks of pain occurred about one-half hour after eating. Upon admittance the patient's chief complaint was vomiting. The vomitus was deeply bile-stained and contained food or fluid taken previous to vomiting. On July 1 one of us (A. V. P.) was called into consultation and the following observations were made: The patient stated that she could not take anything by mouth without vomiting it. The pain was not particularly severe. Vomiting occurred at about five to ten minutes following intake of food or fluid. The epigastric region was slightly distended and tympanitic, and no rigidity was elicited. The patient was rather weak and dehydrated. Past history revealed that the patient had had an appendectomy in 1929 and a thyroidectomy in 1932.

X-ray Report.—Roentgen examination of the stomach showed ptosis of the stomach with the greater curvature extending 5 inches below the umbilicus. The stomach had some difficulty in emptying, and a reverse regurgitation of the duodenal contents was noted. The duodenum was enlarged, and barium passed into the jejunum with difficulty and at irregular intervals.

Operation.—Duodenojejunostomy was performed on July 3.

Comment.—The operative findings revealed the stomach free from ulcers or tumors. Upon lifting the transverse colon the retroduodenum was seen bulging through the mesocolon. It was dilated to about twice its normal size. The small intestine was found collapsed and its mesentery wanting in fat. Lifting of the mesenteric pedicle caused the duodenum to empty into the jejunum. This patient was of the asthenic, thin, visceroptotic type. The cause of the obstruction was apparently due to the absence of mesenteric fat. The patient made an uneventful recovery.

CASE 2.—Megaduodenum due to adherent transverse colon into the pelvis. Mrs. T. F., aged 35 years, was admitted to the Elgin State Hospital on March 2, 1937. She had had abdominal pain for a period of two years. The pain was "cramp-like" in nature, diffusely distributed over the abdomen, but more marked in the epigastrium, and was associated with recurrent attacks of vomiting. In December, 1936, she had been treated for peptic ulcer at the Cook County Hospital.

She entered the Elgin State Hospital for observation. Upon admittance she showed no overt psychotic manifestations. Her chief complaint was vomiting which occurred at irregular intervals, and epigastric pain was associated with food intake. The pain and vomiting ceased while the patient remained in bed. Past history and physical findings: oophorectomy, 1914; appendectomy, 1918; removal of lingual tumor, 1930. Physical examination revealed a well-developed, white female lying comfortably in bed, not appearing acutely ill. Temperature varied from 99 to 100.8°; pulse varied between 80 and 96; blood pressure, 124/86; right McBurney and suprapubic scars on the abdomen; tenderness elicited in epigastrium and upper

quadrants; no muscular rigidity; the ascending colon was tympanitic. Physical findings elsewhere were essentially negative. Serology, blood chemistry, gastric and urine analyses were negative.

X-ray Findings.—The stomach was low in the pelvis. There was a marked dilatation of the first, second, and the beginning of the third portions of the duodenum with reverse peristalsis present. Very sharply demarked limitation of the passage of barium at the midportion of the third part of the duodenum in the region of the spine. The stomach filled readily and rugae were present. The duodenal cap was clearly visualized and smooth in outline. An immediate plate (Fig. 9) revealed the descending and transverse portion of the third part of the duodenum was markedly dilated, measuring about 3 inches in diameter, and sharply terminating over the spine. A six-hour plate (Fig. 10) revealed 60 per cent of gastric residue, with barium remaining in the duodenum and duodenal cap, and some barium present in the terminal portion of the ileum and ascending colon. A twenty-four-hour plate revealed a small amount of barium scattered in the ascending, transverse, and sigmoid colon.

Fig. 9.—Case 2. Compression of the duodenum by the middle colic artery. Immediate plate showing the markedly dilated duodenum which is sharply terminated over the spine.

Operative Findings.—The patient was operated upon on March 19, 1937, seventeen days after admission. Upon opening the abdomen numerous adhesions were encountered. The transverse colon was adherent firmly into the true pelvis by adhesions. There was considerable drag upon the mesocolon. The stomach was slightly dilated; its wall was thin, and the pyloric sphincter admitted two fingers. There was no evidence of ulcers or scars in the stomach wall. Upon lifting the right half of the transverse, the retroduodenum was seen bulging through the mesocolon, and the diameter of the duodenum was estimated to be about 4 inches. The first portion of the jejunum was empty and of normal size; however, its wall appeared to be edematous.

Operative Procedure.—An attempt was made to free the transverse colon from the pelvis, but it was so densely attached that this was impossible. A duodeno-jejunostomy was done between the collapsed jejunum and the dilated retroduodenum.

Follow-Up Notes.—The patient made an uneventful recovery. On April 28, 1937, the fortieth postoperative day, x-ray studies were made. An immediate plate (Fig. 11) revealed the barium passing directly from the duodenum into the jejunum through the new opening. The six-hour plate (Fig. 12) revealed the stomach empty, and most of the barium in the colon. On May 21, 1937, the patient was discharged from the Elgin State Hospital with the following notation: "Patient gained 20 pounds in weight since her operation. She has been discharged from the institution as without psychosis, and having recovered from the acute physical condition."

Fig. 10.—Case 2. Compression of the duodenum by the middle colic artery. Six-hour plate shows 60 per cent residue in the stomach, with barium in the duodenum and duodenal cap.

Comment.—This case illustrates the importance of examining the duodenum in all cases of unexplainable gastric symptoms. X-ray findings, before and after operation, the operative findings, and the complete relief of symptoms following the operation are conclusive evidences that in this case the symptoms were due to a duodenal obstruction, and not the result of peptic ulcer or of a neurasthenic syndrome.

The obstruction was due to the downward and backward pull of the middle colic artery on the duodenum, and not mesenteric traction. The operation of choice would have been a colopexy; however, this was not possible because of the firmly attached transverse colon in the pelvis.

Case 3.—Embryonal band attaching the first loop of jejunum to the transverse mesocolon associated with bleeding and perforating peptic gastric ulcer. Mr. E. L.,

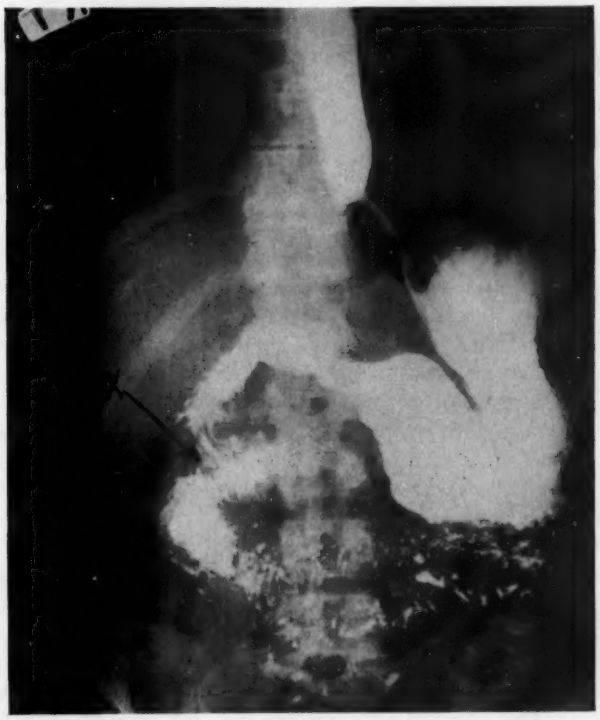

Fig. 11.—Case 2. Compression of the duodenum by the middle colic artery. Immediate plate made on the fortieth postoperative day. Note the barium passing directly into the jejunum through the duodenojejunostomy.

Fig. 12.—Case 2. Compression of the duodenum by the middle colic artery. Six-hour plate, fortieth postoperative day, shows the stomach empty and that the barium has reached the colon.

aged 41 years, a farmer. Since 6 years of age the patient has experienced abdominal distress characterized by nausea, abdominal pain, and vomiting. The pain was located in the epigastrium, was relieved by vomiting, and was not related to food intake. In 1922 a diagnosis of bleeding peptic ulcer was made and he received medication which gave him relief. He was then free from symptoms for about fifteen years. In June, 1938, he had a severe gastric hemorrhage which came on suddenly without previous pain or warning. He was treated medically, about two months being required for complete recovery. In December he began having epigastric pain which was often, but not constantly, relieved by vomiting. Pain upon admittance was dull, extended across the hypochondriac regions, and not related in time to eating. Within the past two weeks he had vomited every day. During the past week his stools had been black and associated with marked constipation. The vomitus was sometimes almost all liquid, brown or greenish in color, but not "coffee-ground" in appearance. The patient was referred to one of us (A. V. P.) with a diagnosis of bleeding and perforating gastric ulcer, as substantiated by x-ray studies.

Physical examination was essentially negative except for some tenderness and slight rigidity in the epigastrium.

Laboratory Tests.—R. B. C., 3,870,000; hemoglobin, 64.9; total protein plasma, 5.85; urine, negative; fractional meal analysis, lowest free HCl, 31 degrees, highest 75 degrees; Kahn test, negative; stool examination showed occult blood, 1 plus.

X-ray Examination.—The following report was given on the x-ray examination made upon admittance at Mercy Hospital:

"The fluoroscopic examination made with the radiopaque medium revealed the emulsion entering the esophagus freely and dilated it normally. There was no evidence of lagging at the cardia. The stomach filled readily with the greater curvature reaching the level of the crest of the ilium in the median line. Peristaltic function was hyperactive with the waves not closing off accurately to the tip due to effects on the lesser and greater curvature of the pylorus at the antrum. The first portion of the duodenum showed a diverticulum in the inferior surface, and several defects on the superior surface. The second portion of the duodenum showed the barium passing through it, without any evidence of peristalsis, in a thin stream. The proximal end of the third portion of the duodenum was markedly dilated, and antiperistalsis was very evident. Patient complained of tenderness upon palpation over the defects.

"The five-hour roentgenogram showed some retention of the barium in the diverticulum, and the remainder of the barium distributed throughout the colon."

Preoperative Diagnosis.—Bleeding and chronic perforation ulcer; chronic duodenal obstruction due to an embryonal band fixing the first loop of jejunum; possible gastroduodenal fistula.

Operative Findings.—There was a stellate scar on the anterior surface of the pylorus. The pyloric end of the stomach and the first part of the duodenum were firmly adherent together, and apparently a fistulous tract communicated between them. The head of the pancreas was slightly enlarged. The first loop of jejunum was found adherent to the transverse mesocolon, and its direction was to the right of the body (Fig. 8).

Procedure.—The embryonal band was excised, and the first loop of jejunum restored to its normal position. A partial gastrectomy was performed.

Pathologic Report.—

"Specimen consists of a pyloric segment of the stomach measuring 14 cm. in length. Peritoneum covering what is apparently the anterior surface of the stomach is smooth and reddish gray in color. That covering which is apparently the posterior aspect seems roughened by torn fibrous adhesions. The mucosa is swollen, reddish

tan in color, and on it red-stained mucous is noted. About 4.5 cm. proximal to the pylorus is apparently a small out-pouching of the wall. This is lined by smooth, reddish tan mucosa. Along the margin of this out-pouching a small depressed area about 4 mm. in diameter is noted. Microscopic diagnosis: subacute perforating peptic ulcer, located at pylorus.''

Comment.—The patient made an uneventful recovery, and at this writing, one year after operation, he is free of all symptoms. This case illustrates the importance of investigating the duodenum when a history of gastric distress dates from childhood.

CASE 4.—Mrs. E. N., aged 64 years. Duodenal obstruction due to carcinoma of the terminal duodenum. The patient was admitted to the Grant Hospital on Aug. 13, 1938, with the history of two previous admittances to the hospital. At first admittance, May 4, 1938, the patient's chief complaint was vomiting. After three days of observation she was discharged with a diagnosis of chronic cholecystitis. Two months later, July 18, 1938, the patient was readmitted, and the following history was obtained: intermittent attacks of vomiting, pain in the upper right quadrant, and some distention of the abdomen. The vomitus was bile-stained. She appeared dehydrated and acutely ill. X-ray examination was made at this time with the following report:

''Esophagus, stomach, and duodenal bulb negative fluoroscopically and radiographically, but the barium nevertheless was held up in the bulb in the erect position and only went through while lying down. There was a small retention in the bulb at the five-hour examination [Fig. 13]. This we believed to be due not to duodenal pathology but to pressure and adhesions from adjoining gall bladder. Gall bladder: suspicion of gall bladder pathology verified by the fact that the gall bladder was not well visualized, but nevertheless, was outlined sufficiently showing it to be distinctly enlarged and undoubtedly pathologic. At the same time some of the dye remained in the stomach, again verifying partial obstruction in the duodenum.''

The patient was operated upon on July 26, 1938, and the gall bladder removed. She continued to vomit postoperatively and on Aug. 5, 1938, she was discharged as having improved.

The patient continued to vomit greenish fluid, and on Aug. 13, 1938, she was readmitted. At this time one of us (A. V. P.) was called into consultation. Examination revealed that the patient was extremely dehydrated, weak, and unable to retain anything in her stomach. The abdomen was distended and tender. The temperature was 102°. After examining the x-ray plates (Fig. 13) that were taken during her previous admission, a diagnosis of acute duodenal obstruction was made, and an operation was advised.

Operative Findings.—The stomach was slightly dilated and somewhat edematous. The pylorus and the hepatic flexure of the transverse colon were adherent to the anterior parietal peritoneum. A tumor about the size of an orange was found to involve the terminal portion of the duodenum. It was hard and rather vascular. There were lymphatic enlargements along the mesentery of the small intestine. Exploration of the pelvic organs, large bowel, and elsewhere in the abdomen failed to reveal any tumefaction. A duodenojejunostomy was performed. The patient died two days later. Unfortunately permission to perform an autopsy could not be obtained.

Comment.—Since the onset of the patient's illness the chief complaint had been vomiting of greenish material. The vomiting became

progressively more pronounced, copious in amount, and finally continuous. Medical treatment and cholecystectomy failed to relieve these symptoms. These facts coupled with x-ray findings indubitably indicated a duodenal obstruction. A tumor was suspected as being the cause of the obstruction because of the sudden onset of the symptoms, and the absence of any previous history of "gastric distress." The patient was in a precarious condition, and a duodenojejunostomy was performed because it was felt that this was the only procedure which offered any hope of relief.

Fig. 13.—Case 4. Carcinoma of the terminal duodenum. Five-hour plate shows retention in the duodenum.

CASE 5.—Mrs. C. A., aged 60 years.* On admission to Mercy Hospital the patient complained of intermittent vomiting associated with pain in the epigastrium, loss of weight (she had weighed 127 pounds about ten months before and at present weighed 79 pounds), constipation, nocturnal frequency, and occasional edema.

The patient stated that she had been well until about one and one-half years before admission when she began to have vomiting attacks associated with pain in the epigastrium. During the past year she had been under medical treatment; nevertheless, the symptoms had become more severe. She had a sick feeling after eating rich foods. During the past few months the condition had been getting much worse, and the patient had lost considerable weight. At present she vomited after each meal, and the vomitus was deeply bile stained. Stools were clay colored.

*This case is reported through the courtesy of Dr. George D. Griffin.

Physical Examination.—The head and neck were essentially negative. The abdomen showed hypogastric tenderness and abdominal distention, and was thin, wrinkled, and inelastic. There was slight tenderness in the epigastrium. The liver edge was palpable. The patient was poorly nourished, emaciated, apathetic, tired, lying quietly in bed and appearing rather acutely ill.

X-ray Examination.—"Fluoroscopic examination of the stomach, by means of barium meal, revealed the emulsion passing through the esophagus freely. The stomach filled readily with the greater curvature reaching below the crest of the ilium, with the patient in the vertical position. The peristaltic function was hyperactive. The pylorus closed off accurately to the tip of the antrum. The first and second portions of the duodenum revealed a marked dilatation, and at no time did any barium pass beyond the second portion of the duodenum due to a stenosis or constriction. The roentgenograms taken immediately after confirm the fluoroscopic findings [Fig. 14]. Five-hour roentgram reveals about 40 per cent of the barium in the stomach [Fig. 15], with about 30 per cent of it in the first and second portion of the duodenum which is markedly dilated."

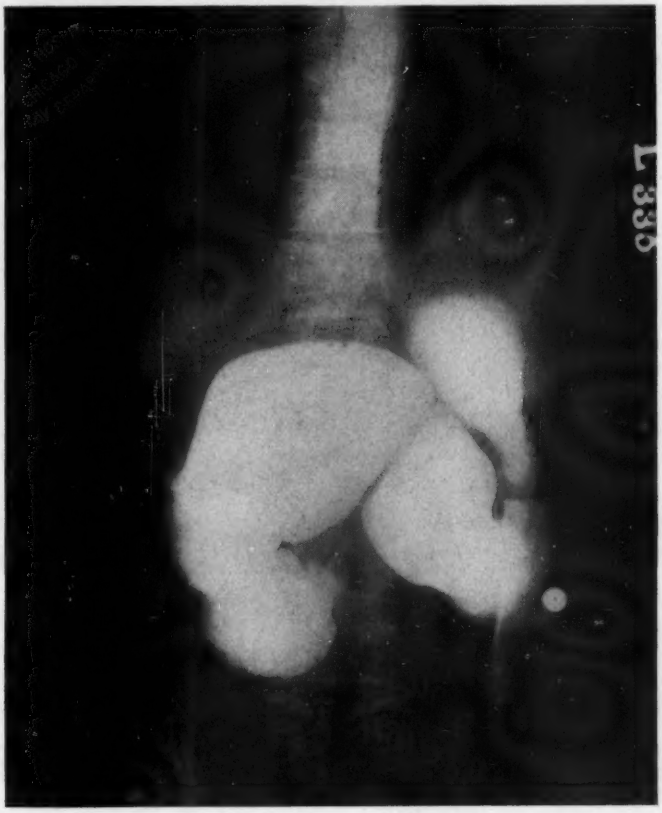

Fig. 14.—Case 5. Hodgkin's disease. Immediate plate showing an enlarged duodenum.

The patient died on Sept. 29, 1939, eleven days after admission. Autopsy was performed by Dr. J. F. Sheehan. The following is a brief résumé of his report: Marked dilatation of the stomach, first, second, and third portions of the duodenum. Pylorus fully 6 cm. in diameter, and the duodenum 6 to 8 cm. The lymph nodes around the origins of the superior mesenteric artery and celiac axis were markedly enlarged, particularly those to the right of the aorta. The posterior aspect (dorsal)

of the root of the mesentery was firmly adherent to the anterior wall of the third portion of the duodenum. Proximal to this area of adhesions the duodenum was markedly dilated; distally the small intestine was partly collapsed.

Microscopic Diagnosis.—Hodgkin's disease, involving the upper abdominal nodes along the aorta, and in the root of the mesentery of the small bowel. Invasion of the wall of the third portion of duodenum by tumor from adjacent mesenteric nodes with formation of large ulcer in the third portion of the duodenum.

Fig. 15.—Case 5. Hodgkin's disease. Five-hour plate shows about 30 per cent of the barium in the duodenum. Arrow indicates the sharply demarcated duodenum.

CASE 6.—Mr. J. S., aged 81 years. Duodenal obstruction due to huge aneurysm of abdominal aorta. The patient was committed to the Elgin State Hospital in 1935 and classified as psychosis with cerebral arteriosclerosis. During January, 1939, he complained of attacks of upper abdominal pain and vomiting of bile-stained fluid. Vomiting seemed to occur more frequently after meals and was followed by relief of epigastric fullness and distress. Examination revealed a thin male 81 years of age, not appearing acutely ill. Essential findings were localized to the abdomen. There was a grapefruit-sized semifirm mass in the epigastrium which extended to the right costal margin, but did not appear to be attached to the liver. Pulsation was present, but did not appear to be expansile in type. Laboratory tests revealed normal blood count, negative urinalysis and blood Wassermann, with an elevation of the N.P.N. to 47.1 mg. and creatinine to 1.90 mg. (elevation possibly due to repeated vomiting). The Ewald test meal revealed 400 c.c. of bile-

tinged fluid with no free hydrochloric acid present. A barium meal showed the stomach filled normally; it was located to the left extending down to the pelvis; the duodenum was distended and filled with barium in its first, second, and third positions up to the lumbar spine (Fig. 16). A four-hour plate revealed 60 per cent gastric residue with some retention in the duodenum; a six-hour plate revealed 40 per cent residue; a twenty-four-hour plate revealed the stomach empty.

Fig. 16.—Case 6. Aneurysm of the abdominal aorta. Immediate plate showing the duodenum filled with barium up to the spine. Note the displacement of the stomach caused by the pressure of the aneurysm.

A diagnosis was made of a subacute duodenal obstruction due to a pancreatic cyst or an abdominal aneurysm. The patient was placed in bed with elevation of the foot of the bed, and given six feedings of a bland diet daily. Surgery was deemed inadvisable due to patient's age. Vomiting stopped, and the patient felt improved. Small frequent feedings and bed rest were continued, and the patient gained 10 pounds (95 to 105 pounds) in a period of three months. He was kept on the infirmary service where he could rest in bed the greater part of the day. Vomiting did not recur.

On Sept. 28, 1939, patient suddenly collapsed and died. The following is a brief résumé of autopsy findings: The abdominal cavity contained large amounts of blood, in the retroperitoneal space and in the mesentery. There were 2,000 c.c. of free blood present in the cavity. The aorta was perforated (3 cm. in diameter) in the posterior wall about 8 cm. above the bifurcation. The aorta from the superior mesenteric origin to its bifurcation was markedly dilated, and formed a sac of about the size of a baby's head. The wall was very thin, and thrombotic masses were present in the sac. The stomach and duodenum were not dilated.

SUMMARY

1. The terminology used to describe the various types of duodenal obstructions is in a chaotic state. We suggest that the term duodenal obstruction be applied universally regardless of the etiological factor.

2. Duodenal obstruction has been classified according to the etiological factors. This classification should be of material aid toward a more complete understanding of the subject. The etiological factors are divided into two general groups; (a) those which are basically of congenital origin, and (b) those which are acquired.

3. The pathologic anatomy of the duodenum has been thoroughly discussed and the pathogenesis of arteriomesenteric obstruction, gastromesenteric ileus, and other types of duodenal obstruction is given.

4. The diagnosis of duodenal obstruction may be easily arrived at in some cases, while in others it may not be so obvious. No single symptom, or combination of symptoms and physical findings, is pathognomonic. A thorough knowledge and familiarity of the subject and the utilization of this knowledge in the differential diagnosis of all obscure upper abdominal diseases are essential to arrive at a correct diagnosis of duodenal obstruction. Careful roentgen studies will confirm the diagnosis in practically every case.

5. Both medical and surgical treatments are discussed. We stress the fact that each case demands individual consideration. Medical treatment for the visceroptotic type is given in detail. Criteria for surgical indications are given, and the choice of operation is also discussed.

6. Six cases are reported: (1) typical arteriomesenteric obstruction, (2) megaduodenum due to adherent transverse colon into the pelvis, (3) embryonal band attaching about 3 inches of the jejunum to the transverse mesocolon associated with perforation and bleeding ulcers, (4) carcinoma of the terminal duodenum, (5) duodenal obstruction by extension of glands from Hodgkin's disease, and (6) duodenal compression due to pressure from an aneurysm of the abdominal aorta.

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OBSTRUCTION OF THE STOMACH DUE TO CONGENITAL DOUBLE SEPTUM WITH CYST FORMATION

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COMPLETE obstruction of the stomach due to a congenital double septum with mucosal cyst formation is a rare anomaly, which is the reason for reporting such a case. A careful search of the medical literature in an effort to obtain more information on the subject revealed one case of a cyst of the stomach causing obstruction at birth. In that case there was a lumen through the stomach which was compressed by the distended cyst. A second case has recently been reported of a congenital prepyloric membranous obstruction in a premature infant.

It has been estimated that congenital obstruction of the upper intestinal tract occurs once in 20,000 infants. We have been able to find only one case reported in the literature of complete obstruction of the stomach by a septum or cyst formation in the newborn infant that survived after operation.

Touroff and Sussman[1] recently reported a case of congenital prepyloric membranous obstruction in a premature infant which was operated upon Sept. 16, 1938, on the fifth day of life, and the patient lived. They describe a true mucous membrane septum obstructing the stomach just proximal to the pylorus which was incised radially in several directions, after which the incision in the duodenum and stomach was closed by doing a Heineke-Mikulicz pyloroplasty. Touroff and Sussman made a survey of literature and were unable to find a report of a similar mucous membrane septum obstructing the stomach.

Our attention was drawn to this subject by the following case which we wish to report:

On Aug. 5, 1937, a Jewish male infant, weighing eight pounds and three ounces, was born at the Washington Boulevard Hospital, Chicago. It was the first child of healthy parents and appeared to be perfectly normal. Six hours after delivery the child vomited chocolate-colored mucus and continued to regurgitate mucus and milk every two to four hours for the following three days. On the third day a small movable mass about 5 cm. in diameter was palpated just above the umbilicus. A diagnosis of an obstruction of the stomach or intestine was made and an immediate operation was advised.

Operation.—Under local anesthesia supplemented by chloroform the abdomen was opened through a right upper rectus incision. The mass which had been palpated was found to be firm and cystlike and located in the distal third of the stomach extending up to the pylorus. No other evidence of pathology could be seen or palpated in the abdomen.

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A longitudinal incision was made into the gastric mass and about 15 c.c. of slightly turbid mucous fluid escaped. By enlarging the incision to about 4 cm. in length it was noted that the cyst occupied the entire lumen of the stomach, and that the lining membrane had the gross appearance of normal gastric mucosa.

A second incision made in the anterior wall of the stomach proximal to the cyst showed the lumen of the stomach to be completely occluded by the cyst. An eight-inch forceps was then forced from the proximal stomach side of the cyst through the septum into the cyst proper and this opening was enlarged by three radial incisions until it was 3 cm. in diameter.

An incision was then made into the duodenum 3 cm. distal to the pylorus, large enough to insert an eight-inch forceps. A similar obstruction was found just proximal to the pylorus, and through this the forceps was pushed into the cyst. This opening into the distal septum was enlarged by three radial incisions making an opening about 2 cm. in diameter.

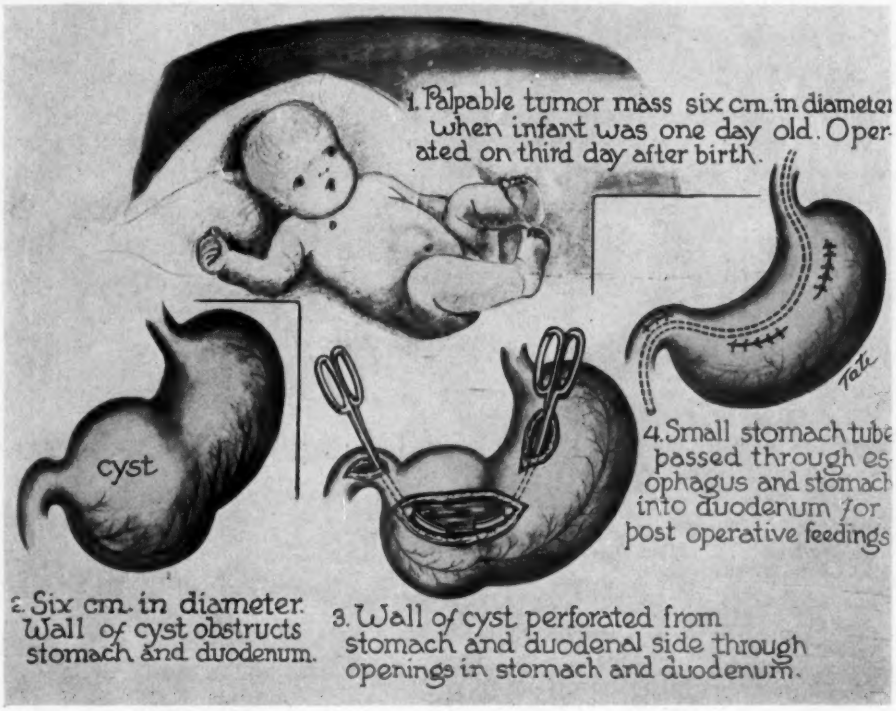
1. Palpable tumor mass six cm. in diameter when infant was one day old. Operated on third day after birth.
cyst
2. Six cm. in diameter. Wall of cyst obstructs stomach and duodenum.
3. Wall of cyst perforated from stomach and duodenal side through openings in stomach and duodenum.
4. Small stomach tube passed through esophagus and stomach into duodenum for post operative feedings
Tate

Fig. 1.

A nasal tube which had been passed into the stomach was now advanced through the openings in the two walls of the cyst into the duodenum.

The incisions in the stomach and duodenum were closed with two rows of sutures and the abdominal incision closed without drainage.

The infant was fed through the nasal tube for two days, supplemented by subcutaneous fluids. On the third postoperative day the child was put to the breast. The one pound and three ounces which the infant had lost during the first three days of life before operation were regained in the next fourteen days. Two weeks after operation the child was so well that he successfully sustained a ritualistic circumcision.

In December, 1940, the boy, 3 years and 2 months old, three feet six inches tall, and weighing thirty-eight pounds, was in excellent health. A roentgenologic

examination of his stomach with a barium meal showed the stomach to be normal in size and shape with no evidence of filling defect. The pylorus was patent and appeared to be functioning normally.

Pathologic Report.—The gross appearance of the lining of the cyst was entirely similar to that of the lining of the stomach. Microscopic examination of sections taken from the septum between the cyst and the stomach showed normal gastric glands on both sides with smooth muscle fibers in between.

From examination of the stomach at the time of operation it was impossible to determine the origin of the cyst. Evidently two septa developed in the stomach with the creation of a closed cavity in between. With the beginning of gastric function the gastric juice in the closed space formed a cyst.

SUMMARY

A case is presented of complete congenital obstruction of the stomach by a mucosal cyst in a newborn infant which was successfully operated upon the third day of life.

The cyst, which was gastric in origin, probably resulted from the formation of two septa in the stomach.

Microscopic examination of the lining membrane showed the presence of gastric glands.

The operative technique as described consisted of re-establishing the lumen through the stomach by perforating the walls of the cyst.

A review of the medical literature shows this condition to be very rare, and this case is reported in order to add to our present small knowledge of this subject.

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SPINAL EXTRADURAL CYSTS

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THE PRIMARY purpose of this report is to record the case records of two additional spinal extradural cysts. This addition brings the total number of proved cases of the malady to 16. The secondary purpose of the report is to re-emphasize the thesis that the lesion is more common than reports thus far would indicate and that the lesion can simulate the clinical picture of degenerative lesions of the spinal cord, especially multiple sclerosis.

In 1934, Elsberg, Dyke, and Brewer[4] reported 4 cases of spinal extradural cyst, 3 of which had occurred in their series of 250 tumors of the spinal cord. The fourth case had been operated upon by Dr. A. S. Taylor. From their study, Elsberg, Dyke, and Brewer presented as the characteristic syndrome the following: "The individual is an adolescent with the history and symptoms of progressive spastic paraplegia. Pain is absent or is not a prominent symptom. The objective disturbance of sensibility is slight and the upper level is in the midthoracic region, usually in the sixth or seventh thoracic dermatome." They also noted narrowing and atrophy of the pedicles of the vertebrae in the middorsal region with widening of the interpediculate space. They theorized that this variety of spinal extradural cyst was due to a congenital diverticulum of the dura or a herniation of the arachnoid through a congenital defect of the dura.

One year later Lehman[7] reported 2 cases of spinal extradural cyst. His cases showed the clinical features which Elsberg, Dyke, and Brewer had described as characteristic of the syndrome, but, in addition, he called attention to x-ray changes in the body of the vertebra, an epiphysitis, which he considered an additional reason for suspecting the presence of an extradural cyst. He also emphasized the great variability in the clinical findings which these lesions produced as compared with other expanding lesions of the spinal canal. He concluded that the cysts were a herniation of the arachnoid through a congenital defect of the dura since in 1 of his cases there was a neck which was patent connecting the cyst with the dura. Elsberg, Dyke, and Brewer had suggested that "if the hypothesis that the cyst is due to herniation of the arachnoid through a congenital defect of the dura is correct, cases might be encountered in which the neck of the sac had not been obliterated."

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Cloward and Bucy[2, 3] reported 2 cases and made an extensive study of the x-ray changes presented by ten of the spinal extradural cysts. They called attention to the fact that the kyphosis seen with spinal extradural cysts is identical with that described as kyphosis dorsalis juvenilis. They concluded that these bony changes are due to compression and occlusion by the cyst of the venous channels draining the vertebral bodies. They also believed that the cyst is a diverticulum of both dura and arachnoid. The case reported by Cloward was unusual in that the cyst occurred in an adult, and its location was in the lumbar region.

Mixter's[9] case was unusual in that the cyst was multilocular.

Peet and Kahn[10] reported a case of spinal extradural cyst in which the principal symptoms were vascular, not unlike those occurring in Raynaud's disease. In none of the other reported cases were vascular phenomena observed.

Meredith[8] reported a case of spinal extradural cyst occurring in the cervical region. This is the only case recorded in the cervical region. He believed the cyst resulted from a trauma with a puncture of the dura by a sliver of bone.

Recently Kelly,[5] Turnbull,[14] and Robertson and Graham[11] have each added an additional case to the literature.*

CASE REPORTS

CASE 1.—M. S., white male, aged 16 years, was admitted to Norton Memorial Infirmary, Louisville, Ky., on Feb. 28, 1937, because of weakness of the legs.

The past and family histories were irrelevant.

The present illness started three years before when the patient fell and wrenched his back badly. He immediately had severe shooting pains down his right leg. Soon both legs became numb and weak, and he was unable to walk. He was bedridden for several weeks at the time with marked loss of sensation from the inguinal region downward. He improved gradually, and, after approximately three months, was able to resume his normal activities.

One year later while driving a truck he applied the brakes suddenly and felt a snapping sensation in his back followed by violent pain which shot down the right leg and, to a less degree, down the left leg. He was able to continue driving for a short while, but when he got out of the truck both legs collapsed under him. Numbness and tingling were present in both legs.

Some improvement of strength in his legs occurred, but he had been unable to walk without crutches for approximately eighteen months. There had never been incontinence of urine or feces. He had suffered no pain for over a year. The weakness of both legs had gradually progressed for the four weeks preceding admission.

Physical examination showed a slightly obese, white male, weighing 220 pounds and measuring 6 feet in height. Both legs were moderately spastic with weakness

*The cases of Schlesinger[12] and Krauss,[6] sometimes included in the reports of spinal extradural cysts, are not considered acceptable as proved cases of the syndrome here discussed.

Cloward and Bucy[3] discovered a report by Blum[1] of a case which was probably a spinal extradural cyst.

Teachenor[13] reported a spinal extradural cyst at the Harvey Cushing Society in Philadelphia in 1937. Certain details of this case were included by Cloward and Bucy[3] through a personal communication, but a complete report has never been published.

more pronounced in the right leg. Knee and ankle jerks were marked exaggerated bilaterally. There was a sustained patellar and ankle clonus and a positive Babinski, Oppenheim and Gordon bilaterally. The upper extremities were normal.

Below the iliac crest there was marked loss of all forms of sensation. Above this point to the level of the eighth dorsal segment the sensory loss was less pronounced. Above the eighth dorsal segment sensation was normal.

Spinal puncture yielded clear, colorless fluid. There was a complete subarachnoid block to Queckenstedt test. X-rays of the dorsal region showed a rather marked kyphosis in the lower dorsal region. The following note was made on the x-ray report: "The anterior margins of the dorsal vertebrae are slightly irregular undoubtedly indicating that the patient has had an epiphysitis early in life and that the picture now present is what is known as juvenile kyphosis dorsalis. The pedicles of the dorsal vertebrae seem to be normal."

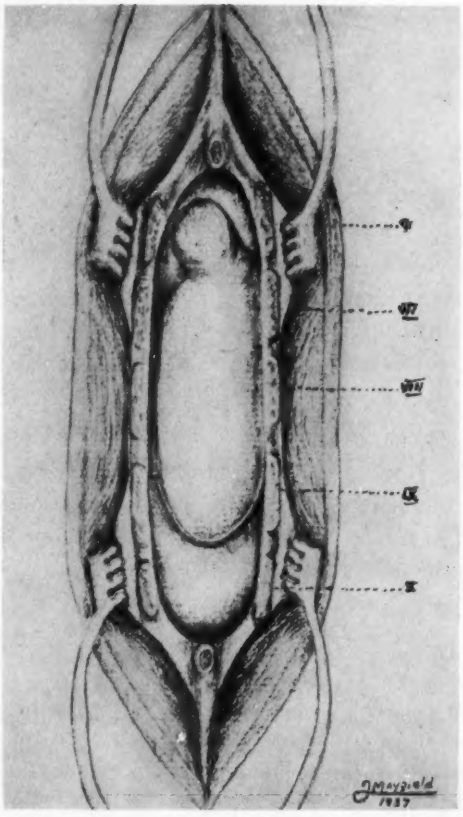

Fig. 1.—Schematic drawing showing the position of the cyst overlying the dural sac. Pressure on the cystic cavity caused it to empty, and compression of the jugular veins immediately distended the cyst.

Lipiodol examination showed an incomplete block at the lower margin of the tenth dorsal vertebra. The lipiodol gradually passed around this obstruction to re-form underneath the ninth dorsal vertebra.

Operation.—On March 8, 1937, a laminectomy of the sixth, seventh, eighth, ninth, and tenth dorsal vertebrae was performed (F. H. M.). When the laminae were removed, a tense cystic mass was exposed which was easily freed from the underlying dura (Fig. 1). As the cyst was being manipulated it became softer and finally collapsed. All of the fluid within the cyst had escaped through the patent

pedicle into the subarachnoid space. When the patient coughed or when the jugular veins were compressed the cyst would refill. This refilling and emptying process was demonstrated several times during the operative procedure. A silver clip was applied to the pedicle and the entire cyst lifted from the wound. The pedicle was attached to the dura near the exit of the ninth spinal nerve on the right side.

Pathologic examination showed a cystic mass measuring 16 by 20 by 60 mm. The microscopic study showed the wall to be composed of dense, white, fibrous tissue similar to that seen in normal dura. The inner portion of the wall was of more loosely constructed connective tissue. A few flattened cells similar in appearance to the arachnoid were found on the inner wall.

Postoperative course was uneventful. At the time of discharge two weeks later, the patient could walk without support, and the sensation was normal. Tendon reflexes were still hyperactive, but there were no pathologic reflexes. He was given a back brace and instructed to wear it for six months.

At our request, the patient returned for examination on Oct. 1, 1940. He stated that he had been employed at heavy work since he discontinued the use of the back brace and had recently volunteered for military service.

Examination at that time revealed a moderately exaggerated dorsal kyphosis and completely normal neurological findings.

Comment.—This case represents two unusual features. The onset of symptoms occurred immediately following trauma. After a short period of definite spinal cord compression, the patient apparently had a complete recovery. A year later, following a second minor trauma, the signs of spinal cord compression recurred. In no other case of spinal extradural cyst has a history of trauma been so closely associated with the onset of symptoms. At operation the finding of a pedicle, which was patent, connecting the cyst and the subarachnoid space afforded proof to the theory that the cysts are arachnoidal herniations that may empty and fill intermittently. At the time of operation the cyst was filled completely and during manipulation emptied into the subarachnoid space. The remission, as related in the history, was probably due to a similar emptying of the cyst.

CASE 2.—C. B., negro male, aged 26 years, was admitted to the Louisville City Hospital on April 1, 1940, because of weakness of the legs. The only significant feature in the past history was that one year previous to the onset of his symptoms he fell from a barn, fracturing his left arm. He could not remember sustaining other injuries at the time.

Twelve years ago the patient noted that the left foot "went to sleep" easily. Soon after the onset of this tingling sensation the left foot became weak, and he was forced to lift it high when walking. Numbness developed in the left leg and gradually spread upward. Soon both legs were involved. By the end of a year he was unable to walk. Both legs felt numb and dead.

It was fourteen months before any improvement was noted. Then the sensation in his legs gradually returned, and he was soon able to get around with the use of a cane. Following his first episode he had weakness and numbness of the legs followed by four definite remissions. He was unable to give accurately the dates of these remissions. With each episode of paralysis the recovery was less complete. For the preceding three years the paralysis had slowly progressed without any semblance of a remission. During the last year he had been bedfast with very

little voluntary movement possible in either leg. His whole body below the umbilicus felt numb and dead. For three months he had noted difficulty in voiding and was markedly constipated. For two or three months he had noted numbness of both hands, and his arms felt clumsy.

This patient was first examined in this clinic in October, 1939. The findings at this time were (1) spastic paraplegia with bilateral ankle clonus and bilateral Babinski responses, (2) diminution in all forms of sensation below the level of the umbilicus, (3) marked incoordination of the upper extremities with a bilaterally positive Hoffmann's sign. In view of the history of remissions and the findings in the upper extremities, a presumptive diagnosis of multiple sclerosis was made, but a complete investigation was advised, including x-rays of the spine and spinal fluid examination. He did not return to this clinic, however, until March, 1940, and at this time the following positive findings were listed: (1) The voluntary control of both lower extremities was markedly reduced. (2) Mass reflexes were easily demonstrated in both lower extremities. (3) Tendon reflexes in both legs were hyperactive. (4) There was bilateral ankle clonus with bilateral Babinski signs. (5) Sensory examination showed a well-marked sensory loss from below the level of the tenth dorsal dermatome. All forms of sensation were equally involved. (6) The reflex activity of the upper extremities was hyperactive, but no pathologic reflexes were demonstrated. (7) *X-rays* of the dorsal spine showed marked atrophy of the pedicles of the sixth and seventh dorsal vertebrae with widening of the interpediculate spaces in these two vertebrae. The sixth, seventh, and eighth dorsal vertebrae were wedge-shaped, characteristic of kyphosis dorsalis juvenilis. (8) *Spinal puncture* showed the fluid to be under 50 mm. of water pressure. There were no cells and no globulin, and the total protein was 270 mg. per cent.

Operation.—On April 8, 1940, laminectomy of the fifth, sixth, seventh, and eighth dorsal vertebrae was performed. The laminae were very thin and atrophic. A cystic tumor with a peculiar bluish discoloration was easily exposed. The cystic mass was separated from the underlying dural sac. In the process of removal the lower pole of the tumor was ruptured and clear fluid escaped; this had the appearance of cerebrospinal fluid. On the lower pole a fibrous pedunculated attachment to the dura was demonstrated just to the left of the midline. Repeated efforts were made to demonstrate the patency of the pedicle; this was never successful. Careful inspection showed the attachment to be to the spinal dura with no attachment to the dura of the seventh spinal root.

Pathologic Report.—(Dr. A. J. Miller.) Microscopy showed that the entire wall was made up of fibrous connective tissue which varied somewhat in thickness and density of the connective tissue. In some portions the collagenous fibrils were abundant and dense and hyaline; in other portions they were of the same character, but fewer and smaller. There was a moderate number of thin-walled blood vessels supplying the tissue. A mesothelial-like lining was present. Here and there throughout the wall were small foci of inflammatory reaction consisting of moderately dense deposits of lymphocytes arranged about blood vessels and some old hemosiderin deposit. (Fig. 2.)

Postoperative Course.—At the time of his discharge, on April 28, 1940, all motion of the lower extremities had returned, but he was still very weak. Complete sphincteric control had returned. The sensory line at the umbilicus was still present, but hypesthesia was less marked than on admission. Sustained patellar and ankle clonus was present, but no Babinski was obtained. Abdominal reflexes were absent.

The patient was last seen on Sept. 13, 1940, six months after his discharge from the hospital. The strength in his legs had improved to the extent that he had been doing farm work for the preceding two months. His legs were still handled with a little difficulty. The examination showed a mild hypesthesia below the iliac crest.

The abdominal reflexes were weakly active. The knee and ankle jerks were hyperactive. There was an unsustained ankle clonus but no Babinski.

Comment.—Points to be noted in this case are the history of trauma antedating the onset of symptoms, the four distinct remissions, and the marked, long-standing paraplegia with marked sensory loss which was followed by prompt, postoperative improvement. The pedicle attaching the cyst to the dural sac, while at the level of the emerging nerve root, was nearer the midline posteriorly than it was to the nerve root itself.

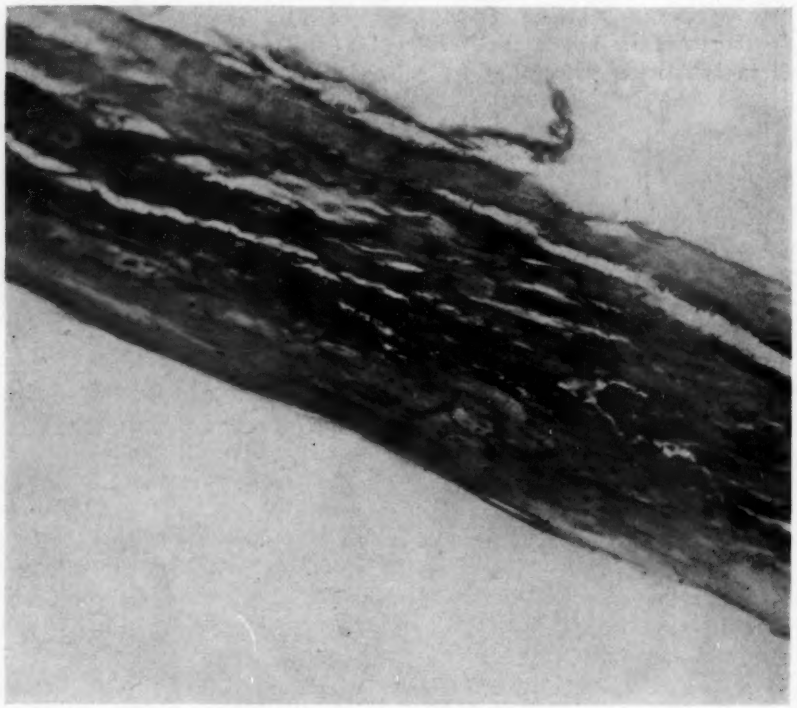

Fig. 2.—Photomicrograph of the cyst wall. Note the mesothelial-like lining, the lymphocytes about the blood vessels and old hemosiderin deposits.

DISCUSSION

The first case demonstrated more accurately than any of the sixteen proved cases the communication of the cyst with the subarachnoid space. Such a finding was predicted by Elsberg, Dyke, and Brewer, who thought this would be confirmatory evidence of a herniation of the arachnoid through defect in the dura. Lehman[7] accepted this theory since his case indicated that the pedicle was patent.

It has been assumed by those who discussed the etiology that a congenital defect was present in the dura. The role of trauma in the production of the arachnoid herniation has received scant attention. Case 1 of this report indicates that trauma may be the exciting cause of symp-

toms. It may be assumed, therefore, that even though a congenital defect be present, trauma may produce herniation of the arachnoid through a congenital dural defect to form an extradural sac. All but one of the reported cases had onset of symptoms in adolescence, the majority of the patients being between 12 and 16 years of age.

Case 2 graphically illustrates the danger of dismissing these lesions as a degenerative disease. Other cases in the sixteen reported have been thought to be atypical multiple sclerosis at some time during the study. It is easy to understand why the case here presented was diagnosed as multiple sclerosis. The marked paraplegia with less marked loss in sensation and history of four remissions, plus the history of mild involvement of the upper extremities, might easily cause one to place the diagnosis in the category of atypical multiple sclerosis. On reviewing the cases reported it is found that remissions have not been an uncommon occurrence. Four have had spontaneous remissions and three others have been secondary to hyperextension. Lack of a history of pain, as is usual in these cases, plus a history of remissions, is very likely to mislead the examiner into making a diagnosis of nonneoplastic lesion. We feel that any patient with the onset of paraplegia in the adolescent period should have x-rays of his dorsal spine and a spinal puncture to eliminate the possibility of spinal extradural cyst.

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A CASE OF SHOCK AND HYPERPYREXIA INDUCED BY INTRAVENOUS GLUCOSE INFUSION*

Its Treatment

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ALTHOUGH reactions following the intravenous injection of aqueous solutions of saline and glucose are not uncommon in hospital practice, the mild nature of these reactions seldom requires any therapy other than a cessation of the infusion. Fever, chills, vomiting, and gastrointestinal disturbances are the most frequent manifestations, with the fever usually subsiding spontaneously in four to six hours.[1] Such conditions, as well as hyperpyrexia accompanying heat and sunstroke, are not usually considered by the clinician to be of the nature of shock, and are not treated accordingly. Shock with hemoconcentration and other pathologic changes accompanying therapeutic hyperpyrexia has been described.[2, 3]

Recently we have observed a case in which hyperpyrexia (109° F. rectally) developed during an infusion of saline and glucose solutions, and was followed by severe shock. The therapeutic effect of some of the more commonly accepted drugs, and, of human serum, as agents in the treatment of this type of shock was studied by means of repeated laboratory determinations.[3, 4] At first drug therapy alone was employed and this period served as a control. This was followed by the institution of human serum therapy, in addition to the supportive measures already employed. The very favorable response to the latter form of therapy has prompted us to report the following case.

CASE HISTORY

W. S., white, male, aged 67 years, entered Michael Reese Hospital on April 13, 1940, with a clinical picture of acute sepsis. No definite diagnosis could be established. Sulfonamide therapy seemed to be ineffective. Six weeks after admission, a thrombophlebitis of the left leg associated with edema of both lower extremities appeared and shortly afterward the fever subsided. He gained over 15 pounds in four weeks, and was discharged to a convalescent home in fairly good condition.

Two weeks later he again began to show evidence of sepsis with daily fever of 101 to 103° F.,† and was readmitted to the hospital. He appeared acutely ill and showed evidence of recent weight loss. The clinical impression supported by x-ray evidence was that of chronic fibroid apical tuberculosis (inactive) and a probable subsiding bronchopneumonia. Daily temperatures of 104° F. were recorded. Sulfapyridine, sulfathiazole, and blood transfusions did not improve his condition. He appeared more toxic and the pulmonary findings were more extensive.

*Aided by the Rosetta Josephson Fund.

†All temperatures taken rectally.

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On Sept. 23, 1940, the patient showed marked dehydration (temperature 104° F.; pulse, 130; respirations, 22), and therefore was given an intravenous infusion of 5 per cent glucose in normal saline solution. After about 100 c.c. of the solution had been administered, he suddenly developed a severe chill accompanied by cyanosis, tachycardia, and shallow rapid respiration (temperature, 105° F.; pulse, 130; respirations, 30). His blood pressure fell to 80/50. The infusion was discontinued, and 1 c.c. of 1:1,000 adrenalin hydrochloride was given intravenously. At 3:30 P.M. the patient was perspiring profusely, incontinent, and vomiting coffee-brown material (temperature, 106° F.; pulse, 134; respirations, 36). He was placed in a cold pack, but his temperature continued to rise to 109° F., the pulse was imperceptible, and the blood pressure was 50/30 at 4:00 P.M. At 4:30 P.M. his temperature was 108° F., pulse imperceptible, respiration rapid and shallow, blood pressure 40/?. The hematocrit reading of 62 indicated hemoconcentration. Oxygen and external heat were administered and the foot of the bed elevated. Repeated intramuscular and intravenous injections of 15 to 20 mg. of paredrine had no appreciable effect on blood pressure. After drug therapy and supportive measures had been employed without effect, 500 c.c. human serum was administered intravenously at 11:00 P.M. Blood pressure rose to 56/40 and temperature dropped to 104° F.; a hematocrit of 48 indicated that hemoconcentration had been overcome (11:30 P.M.). Another intravenous infusion of 500 c.c. of serum with 1,000 c.c. of glucose-saline solution was administered during the night.

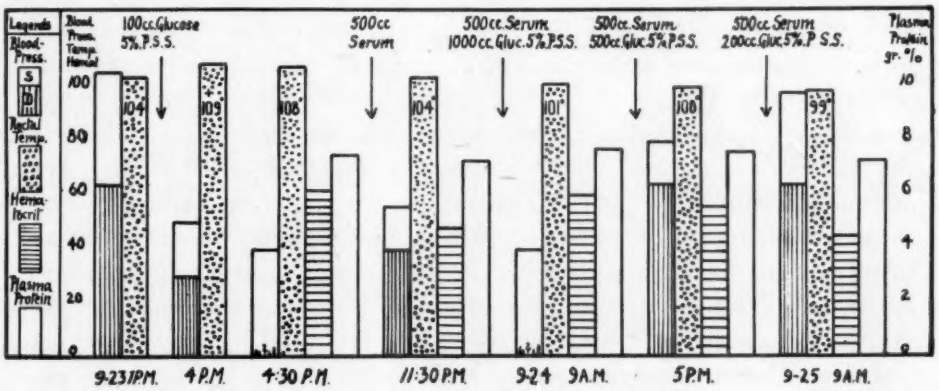

Fig. 1.—Graphic presentation of blood pressure, rectal temperature, hematocrit, and plasma proteins. The arrows indicate intravenous infusions. The first infusion of 100 c.c. 5 per cent glucose in physiologic salt solution was followed by hyperpyrexia and shock. Shock is indicated by low blood pressure (diastolic pressure could not be obtained), and high hematocrit (i.e., hemoconcentration). Supportive measures were of no avail, and are recorded in the body of the paper. Normal human serum with glucose in physiologic salt solution intravenously with supportive therapy were eventually followed by return of blood pressure and normal blood concentration. Specific gravity of plasma and total plasma proteins were determined by a modified Barbour and Hamilton falling-drop method.

On the following day, Sept. 24, 1940, at 9:00 A.M., blood pressure had again dropped to 40/?, temperature was 101° F., and hemoconcentration had reappeared (57 hematocrit and increased plasma protein level). The patient was stuporous and presented the picture of grave shock. At 4:30 to 5:00 P.M., an infusion of 500 c.c. of serum with 500 c.c. glucose-saline solution raised the blood pressure to 80/63, and diminished hemoconcentration appreciably (hematocrit, 54). During the night another intravenous infusion of 500 c.c. of serum and 200 c.c. of glucose-saline solution was administered.

On Sept. 25, 1940, at 9:00 A.M. (temperature, 99° F.; pulse, 118; respirations, 26), clinical evidence of shock was no longer present; blood pressure was 98/72 and later on rose to 104/70; hematocrit readings were normal (45); plasma pro-

teins were 7.3 Gm. per cent. The patient was now mentally alert and responded to all questions. Oxygen therapy was discontinued. The patient continued to be fairly well until on Sept. 29, 1940, when the pneumonic process extended. From then on the course was steadily downhill and he died on Oct. 3, 1940.

Necropsy findings were as follows: bilateral focal and confluent bronchopneumonia and chronic fibroindurative tuberculosis of the lung, involving the left apex; a moderate degree of bronchiectasis. A primary, ulcerative squamous-cell carcinoma of the lower portion of the esophagus with metastasis to the periesophageal and periaortic lymph nodes was an unsuspected finding. Although the entire wall of the esophagus was involved, the carcinoma was nonobstructive and it did not invade the mediastinum. The cause of the obscure fever was most likely due to the carcinoma and the lymph-node metastases. Death was due to inanition and a terminal bronchopneumonia.

DISCUSSION AND CONCLUSIONS

An infusion reaction in a debilitated patient resulted in an unusually severe hyperpyrexia, which was followed by profound shock. The manifestations of shock were an initial high hematocrit reading of 62 indicating hemoconcentration, two and one-half hours after the onset of the reaction; plasma proteins of 7.5 Gm. per cent; and a blood pressure of 40/?. The initial immediate treatment consisted solely of accepted supportive measures which did not appreciably affect the clinical status of the patient. Eight and one-half hours after the onset of hyperpyrexia and shock, normal human serum was given intravenously, and after 500 c.c. had been administered the hematocrit level had fallen to 48. The plasma proteins were 7.4 Gm. per cent, and the blood pressure was 56/40. Although nine and one-half hours later the blood pressure had fallen again, persistent intravenous therapy with serum supplemented by fluids (obtained from a different source than that which incited the reaction) resulted in steady improvement, until all evidence of shock had disappeared, the hematocrit being 45, the plasma proteins 7.3 Gm. per cent, and the blood pressure 98/72.

The treatment of shock in which hemoconcentration, diminished circulating blood volume, and reduced volume flow are prominent factors[4] has been shown both experimentally and clinically to be best controlled by the restoration of the fluid balance with fluids which will remain in the circulation for the greatest length of time. Normal serum and plasma best meet these requirements.[7, 8] The importance of controlling fluid therapy has been stressed.[4, 5] The recovery of this severely debilitated patient from shock accompanying hyperpyrexia indicates the value of human serum in the therapy of this type of shock and the distinct advantage of following the course and therapy with laboratory procedures.

SUMMARY

An intravenous infusion of saline-glucose solution was followed by extreme hyperpyrexia and severe shock. The usual supportive therapy

was without avail. The intravenous administration of normal human serum, in addition to the instituted therapy, brought the patient out of shock and restored normal circulation.

Hyperpyrexia is usually not recognized by clinicians as a possible cause of shock and therefore is not treated as such.

Our experience demonstrates that shock following infusion reactions may be very severe and that therapy has to follow the same principles as applied for other causes of shock, in which hemoconcentration, diminished blood volume, reduced volume flow, and low blood pressure are prominent features.

It is evident that restoration of normal circulating volume is imperative, and that only such fluids as serum or plasma, which will stay in the circulation, should be employed.

Adequate fluid therapy and clinical progress can best be controlled and maintained by blood studies.

We wish to acknowledge the advice and help of Dr. H. Necheles and Dr. S. O. Levinson.

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THE EFFECT OF INTRAVENOUS THEOPHYLLINE WITH ETHYLENE DIAMINE (AMINOPHYLLINE)* UPON THE RATE AND DEPTH OF RESPIRATION

Clinical Study

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ASKANAZY reported in 1895 the use of caffeine and theobromine salts in the treatment of cardiac dyspnea. Since then, numerous investigators have studied the reaction of these drugs both in patients and in the experimental animal. Favorable results are reported by the majority of observers in the administration of these drugs for cardiac failure and cardiac pain.

Greene and co-workers have shown that the favorable influence of the intravenous administration of theophylline with ethylene diamine upon dyspnea is related to a fall of venous and intrathecal pressures. The arterial pressure does not seem to be affected. This would suggest a central action of the drug.

Smith and Sauls demonstrated an increase in skin temperature of the extremities for a period of three hours following intravenous administration of the drug.

Binger advocates its use in intravenous dextrose solution to increase diuresis and improve renal function. He states that there is less reaction to the intravenous administration of fluids when aminophylline is added to the solution.

Impressed by the deep and regular respiration induced by the intravenous administration to patients with Cheyne-Stokes respirations, it occurred to one of us (L. S.) that it might be worth while to administer the drug to patients during the immediate postoperative period to encourage increased diaphragmatic excursion and greater pulmonary ventilation as a prophylactic measure against postoperative atelectasis and subsequent pneumonia.

As far as we can determine, there have been no direct studies made on the effect of aminophylline on the rate and depth of respiration in man, nor of its use postoperatively to increase pulmonary aeration in an effort to prevent atelectasis.

This study was carried out upon patients in surgical wards of the University Hospital while they were awaiting operation and during their immediate postoperative convalescence.

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*Ampoules of aminophylline were supplied by G. D. Searle & Co.

Received for publication, July 28, 1941.

PROCEDURE

Ambulatory patients were required to rest fifteen minutes prior to the experiment. The mouthpiece of the usual basal metabolism apparatus was inserted into the patient's mouth. In some cases, a tight-fitting surgical anesthetic mask was utilized instead of the mouthpiece. The rate and depth of respiration were recorded on a revolving drum in the same manner as a basal metabolism tracing. The blood pressure and pulse rate were recorded prior to the injection and at intervals of two minutes and ten minutes after the injection. The depth of respiration was measured in centimeters of needle excursion on the kymograph and the figures obtained transposed into cubic centimeters for volume of air inspired. The dosage of drugs administered was 0.48 Gm. aminophylline intravenously in one series of experiments, and 2 c.c. coramine intravenously in another series of experiments. Injections of normal saline solution were administered in a third control series.

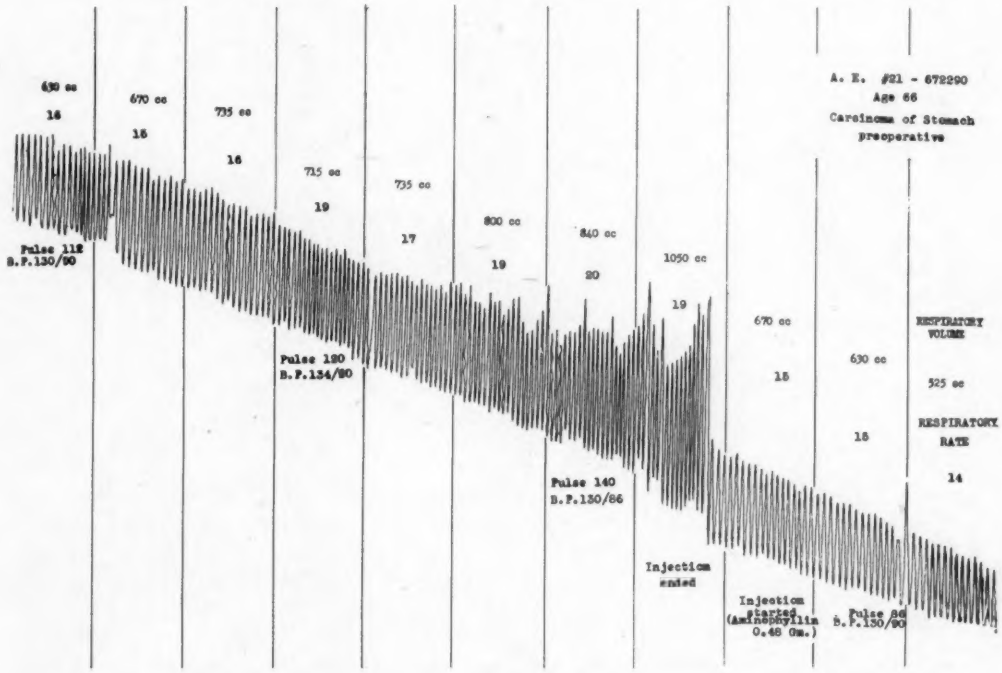

Fig. 1.—Respiratory tracing illustrating the effect of the intravenous administration of aminophylline.

RESULTS

Twenty-two patients with no evidence of pulmonary involvement and three patients with postoperative atelectasis were given aminophylline. Of the twenty-two normal cases, there was a maximum immediate increase in rate averaging 26 per cent and an immediate increase of depth of respiration averaging 51 per cent. All cases showed an increase in the rate or depth or both occurring during the injections or

TABLE I

AMINOPHYLLINE SERIES

(0.48 GM. INTRAVENOUSLY)

NAME	AGE	NORMAL RESPIRATORY RATE/MIN.	FASTEST RATE AFTER INJECTION	TIME TO FASTEST RATE IN MIN.	DURATION OF CHANGE IN RATE IN MIN.	NORMAL VOLUME OF RESPIRATION IN C.C.	VOLUME AFTER INJECTION IN C.C.	TIME TO GREATEST VOLUME IN MIN.	DURATION OF CHANGE IN RESPIRATORY VOLUME IN MIN.
R. P.	60	21	29	0	11.0	840	1,210	0	11.0+
L. C.	35	30	36	7.5	11.5	480	820	0	11.5+
A. K.	53	19	25	0.5	0	545	920	0	11.5+
C. H.	61	15	15	0	0	840	1,150	0.5	9.5+
E. B.	38	23	23	0	0	630	900	2.0	10.0+
E. B.	38	18	18	0	0	795	1,050	0	10.0+
B. F.	18	22	26	1.5	5.5	440	900	0	14.0+
A. V.	66	20	26	3.0	9.0	585	840	3.0	9.0+
A. C.	60	10	12	0	0	1,050	1,465	1.0	14.0+
E. F.	64	15	18	(0)	(0)	690	945	0	6.0
H. W.	43	24	29	0	6.0	1,255	1,570	0	6.0
C. M.	58	18	25	0	11.5	375	480	0	0.5
M. Me.	47	9	12	0	1.0	1,320	1,300	0	2.0
J. M.	45	10	22	2.0	11.0	735	1,170	0	6.0
A. Kn.	63	16	21	3.0	12.0	585	1,150	0	4.0
M. D.	21	9	13	1.5	8.5	945	860	0	0
C. Br.	64	17	20	2.0	5.5	565	820	0	4.5
A. E.	66	15	20	0.5	5.3	545	1,130	0	6.5
C. Bj.	70	17	26	14.0	15.5	375	565	3.5	20.5+
A. H.	47	16	19	0.5	2.5	505	735	2.5	11.5+
A. Ke.	19	14	25	4.0	13.0	505	670	0	2.0
M. Mi.	72	18	18	0	0	585	860	0.6	5.6
Average		17.1	21.5	2.65		652	980	0.6	

Average maximum increase in respiratory rate 26%
Average maximum increase in respiratory volume 51%

TABLE II

CORAMINE SERIES

NAME	AGE	NORMAL RESPIRATORY RATE/MIN.	FASTEST RATE AFTER INJECTION	TIME TO FASTEST RATE IN MIN.	DURATION OF CHANGE IN RATE IN MIN.	NORMAL VOLUME OF RESPIRATION IN C.C.	VOLUME AFTER INJECTION IN C.C.	TIME TO GREATEST VOLUME IN MIN.	DURATION OF CHANGE IN RESPIRATORY VOLUME IN MIN.
B. 2 c.c.	23	21	22	0	0	610	630	0	0
A. B. 2 c.c.	33	19	17	0	0	545	755	0	1.0
M. C. 2 c.c.	48	18	19	0	0	735	795	1	0
G. P. 2 c.c.	19	25	23	0	0	480	610	1.5	10.0(?)
A. E. 2 c.c.	40	21	21	0	0	735	820	4	0.5
E. R. 3 c.c.	22	14	15	0	2	920	1,150	0	1.0
R. 1 c.c.		17	22	8	2	400	420	1	1.5
S. 1.5 c.c.	44	19	22	0.5	1	420	480	0	1.0

immediately afterward. In one case, the increase in rate persisted for more than thirty-five minutes. There were no significant changes of the pulse rate. None of the patients complained of any subjective ill effects.

Coramine in doses of 1.5 and 2 c.c. intravenously was given in eight cases. There was comparatively slight increase of rate and depth of respiration and no significant action upon the blood pressure and pulse in any of the patients without evidence of respiratory or cardiac depression; i.e., normal patients.

Three patients given saline solution intravenously in a control experiment showed no significant changes in rate or depth of respiration.

In the three cases of atelectasis which were studied, the administration of 0.48 Gm. of aminophylline intravenously at four-hour intervals was followed by the disappearance of the rhonchi and the symptoms incident to the bronchial obstruction. It must be stated, however, that other measures such as encouraging the cough reflex, steam inhalation, and postural drainage were also employed.

Aminophylline was given routinely at the University Hospital to sixty-nine cases of abdominal operation and in private practice to over 100 similar cases. Only three developed respiratory complications. This series is much too small to permit any conclusions. We hope to be able to report a larger series in the future.

SUMMARY

Intravenous administration of theophylline with ethylene diamine (aminophylline) increases the rate of respiration 26 per cent and produces an increase in depth of respiration approximately 51 per cent, when administered to normal individuals. There is comparatively a similar effect, but to a much smaller degree, when 2 c.c. of coramine is administered.

In view of these observations and favorable clinical impressions aminophylline in doses of 0.48 Gm. two or three times daily given in intravenous solution is recommended as a prophylactic measure for the prevention of postoperative respiratory complications. The procedure seems to have merit and warrants further investigation and clinical trial.

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POSITIONING IN SURGERY OF THE EXTREMITIES

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SURGICAL operations of the extremities are often more difficult than those of the abdomen. The principal cause of this increased difficulty is the relative inaccessibility of the incision on the extremity. Thus incisions on the mesial, lateral, and posterior surfaces of the arm or leg are not as easy to expose as the more infrequent anterior incisions.

Of distinct aid in operating is to tilt the patient in order to place the area for incision on a horizontal plane facing the ceiling. It may seem trite to speak of placing sandbags under the hip or shoulder, but such simple procedures are still frequently neglected, while the orthopedic surgeon sweats and strains.

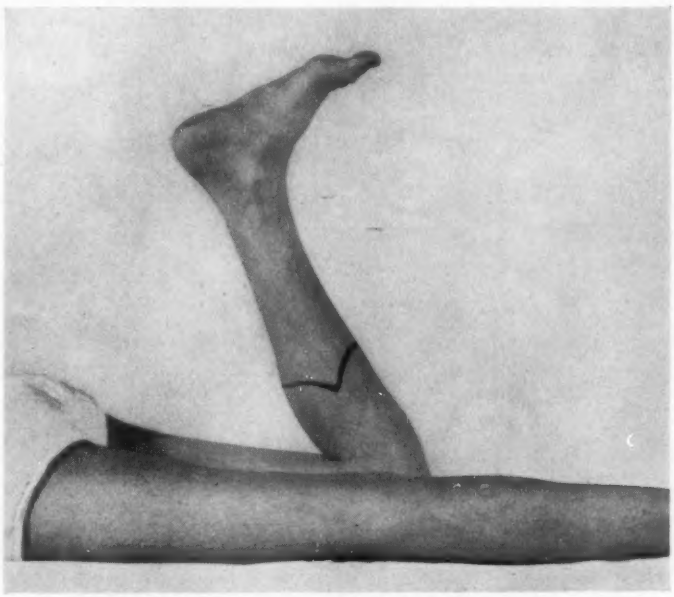

Fig. 1.—Position for lower leg amputations.

In operations of the tarsal region, such as in triple arthrodeses, facility will be increased by flexion of the patient's hip and knee in addition to rotating the hip joint externally or internally as the case may be.

Operations on the posterior aspect of the leg should be done with the patient prone on the table.

The force of gravity should be used whenever practical. This becomes applicable when exploring the various joints of the body. It is common

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practice to allow the exposed knee joint to hang over the edge of the table, thus separating the joint surfaces. How often, however, is the same principle applied to the shoulder joint by placing the patient in a sitting position for operation? In this position the weight of the arm separates the shoulder joint surfaces. An added advantage of this position is the operator's ability to introduce instruments without the obstructing table to hamper him.

Surgical amputations are made easier by proper positioning of the patient.

For lower leg (tibial) amputations, the patient should lie prone on the table. With the posterior surface of his leg exposed, the important posterior tibial artery and nerve may be found and ligated. For the anterior portion of the incision and in order to ligate the anterior tibial artery and nerve, the surgeon flexes the knee. When a lower leg amputation is done with the patient supine, operating on the posterior portion of the leg becomes a gymnastic feat.

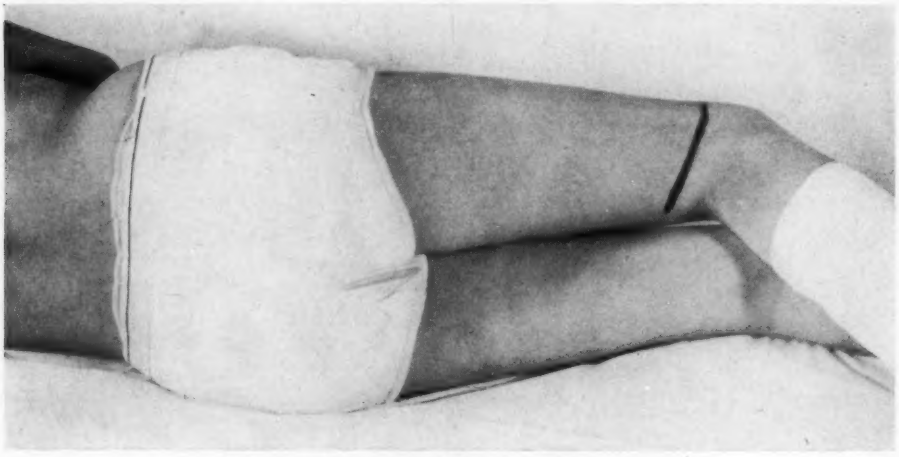

Fig. 2.—Position for thigh amputations.

For thigh (supracondylar) amputations, the patient should lie on his sound side; thus, the important popliteal artery vein and common popliteal nerve face the operator. With the heel of the diseased leg resting on the table the hip joint can be rotated to expose anterior and mesial portions of the thigh.

SUMMARY

A frequently neglected measure in operations of the extremities is to place the patient in the correct position on the operating table. The correct position for each operation is that posture that renders the operative wound most accessible to the operator.

POLYOSTOTIC FIBROUS DYSPLASIA

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SEVERAL recent case reports have called attention to multiple cystic bone lesions which do not fit into the usual classifications of bone disease and whose recognition as a definite clinical entity is now accepted. X-ray study of cystic bone lesions has led to numerous classifications, which, while helpful, are based on unsatisfactory and incomplete clinical and laboratory evidence in some instances.

The term cystic in this discussion is used to describe a circumscribed area of decrease in normal bone density in the roentgenogram, remembering that it is not easy to differentiate by x-ray between a true cyst filled with fluid and a circumscribed defect of bone filled with fibrous and osteoid tissue. If it can be generally appreciated that there exists a group of cases which may resemble, but whose etiology is in no manner related to, hyperparathyroidism, needless surgery may be avoided.

Jaffe in his very comprehensive and excellent treatise on hyperparathyroidism in 1933 in commenting on the cases of Hirsch, Willich, Bradfield, and Telford stated: "My impression is that these conditions are neither Recklinghausen's nor Paget's disease and that they constitute a still unidentified entity. I strongly suspect that they have a congenital basis."

In 1934 Freund reported the case of a girl 7 years of age who suffered a fracture of the right femur through cystic areas. This was followed by varus deformity and shortening. X-rays demonstrated typical multiple bone involvement with characteristic roentgenograms. Despite normal blood calcium and phosphorous levels, neck exploration was performed with negative results. This author arrived at several conclusions: (1) The lesion was primary in the diaphysis and not in the epiphysis or epiphyseal plate as in Ollier's disease. (2) The localized and generalized forms of osteitis fibrosa are separate entities. He discusses the possibility of aberrant embryonic tissue as the underlying etiological factor. (3) He pointed out again, as had Jaffe, that osteitis fibrosa was a nonspecific response to varying stimuli and that the duration, locations of lesions, and x-rays were the important factors in establishing the diagnosis.

Again in 1936 Meffert and Freund, discussing nongeneralized fibrous osteodystrophy, described three cases which revealed characteristic osteoporotic changes limited to monomelic rather than unilateral distribution. Blood chemistry in all cases was normal, and hyperostotic changes occurred only at site of fractures.

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Albright and associates in 1937 described a syndrome in children characterized by skin pigmentation, precocious sexual development in the females, disseminated osteitis fibrosa cystica, normal blood chemistry, and no evidence of parathyroid adenomas. While the reported cases since this paper have been chiefly male adults, there has been no history of sexual precocity. I have examined Campbell's case of a young adult, and it appears probable that adequate follow-up of children and young adults will reveal a status approximating the more recently described adult cases.

To Lichtenstein in his classical paper in 1938 must be given credit for the name which is simple and from both x-ray and microscopic viewpoints accurate, polyostotic fibrous dysplasia. His excellent review and series of eight cases leave little doubt that there are individuals who in the past have been diagnosed as having hyperparathyroidism and Ollier's disease who belong to this entity.

In 1939 Horowitz and Cantarow described a male with a nine-year follow-up who showed increasing deformity of both femora. X-rays and biopsy were characteristic.

Moehlig and Schreiber in 1940 described a 16-year-old boy with a mass in the right occipital region. The right femur, ilium, tibia, and fibula as well as the skull were involved. Interestingly enough, there were changes in secondary sex characteristics, puerile breasts and feminine voice being notable.

CASE REPORT

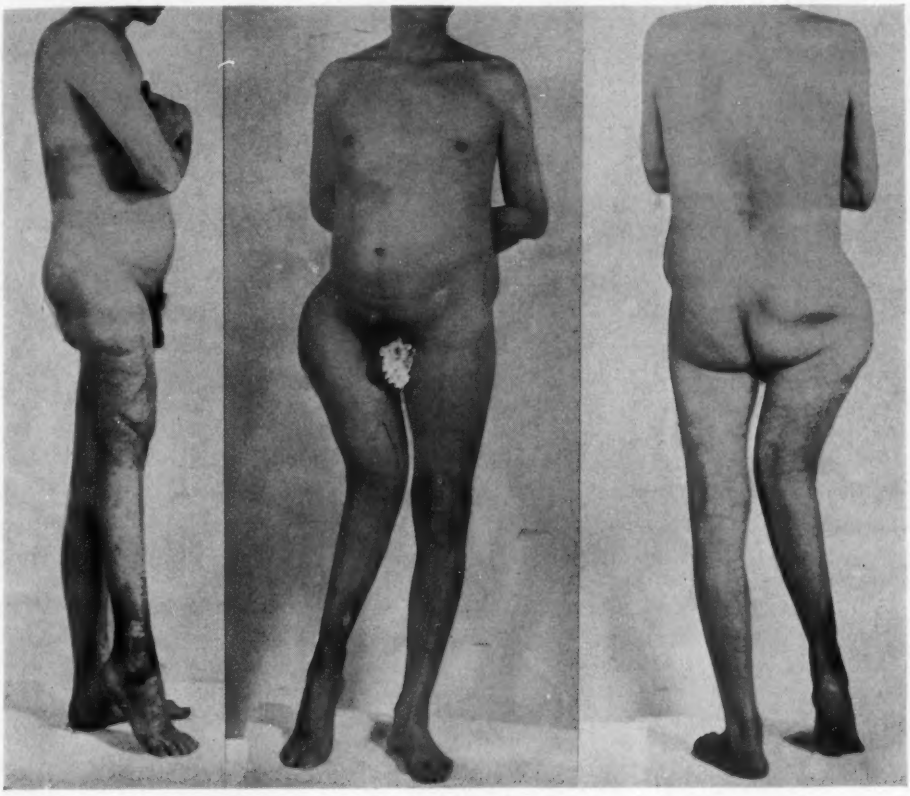
A white male, 57 years of age, entered the Cincinnati General Hospital on Dec. 11, 1939, because of pain, swelling, and disability of the right knee. He gave a history of having fallen in 1903, suffering a fracture of the right femur in the upper third. An immediate open reduction was done and a "wedge" of bone resected for correction of existing deformity. An uneventful convalescence followed, but upon beginning weight-bearing he noticed that there was considerable lateral bowing of his thigh.

In 1923 he began to observe soft, painless masses in the upper two-thirds of the right thigh and around the right hip laterally and posteriorly. At this period they were fluctuant and could be moved under the skin; later they became firm, "like a rubber ball," and fixed. During the past five years many other such tumors have appeared, and for the past ten to fifteen years there has been a progressive lateral bowing of the right thigh and shortening of the extremity. Since 1928 he has had pain of increasing severity in the right knee, but he managed to continue to work until five days before this hospital admission.

Examination revealed the right thigh to be approximately 25 per cent larger than the left with marked lateral and anterior bowing of the femur as seen in Fig. 1. There was shortening of 7 cm. of the right lower extremity, limited entirely to the femur.

The increase in circumference of the thigh was due to numerous discrete, nontender, movable masses of firm consistency, extending from the level of the knee to the crest of the ilium, involving both buttocks and paravertebral regions at the lumbar level. These varied in size from 1 by 1 cm. to 8 by 10 cm. The larger were fluctuant, all were more or less movable, and none were fixed to the skin.

There was only twenty degrees of motion at the knee which the patient attributed to his unwillingness to flex this joint because of pain at the site of trophic ulcers over the tibial crest which had been present since 1937. Fig. 1 reveals two café-au-lait areas of pigmentation over the right flank posteriorly and over the dorsal spine just to the left of the midline.



A. *B.* *C.*

Fig. 1.—Scar over greater trochanter site of surgery in 1903. Other incisions due to knee arthrodesis and biopsies. Notice the large superficial tumor in the region of the right posterior superior iliac spine. Areas of pigmentation along the left paravertebral and right chest wall are clearly visible. Pigmentation about right ankle due to vascular disturbances.

LABORATORY DATA

	CA	P	PHOSPHATASE
12/13/40	8.0 mg.	3.2 mg.	4.6 Bodansky units
12/14/40	7.0 mg.	3.2 mg.	5.6 Bodansky units
12/15/40	8.1 mg.		
12/23/40	9.0 mg.	3.2 mg.	4.4 Bodansky units
2/12/41	10.8 mg.	2.7 mg.	5.8 Bodansky units
2/14/41	11.2 mg.	2.5 mg.	6.5 Bodansky units

Kahn test, negative
CO_2 combining power, 51 volumes %
Urea *N*, 12 mg. %
N.P.N., 22 mg. %
Serum protein, 5.2%
Serum albumin, 2.3%
Serum globulin, 2.9%
B.M.R., –11

Over a six-day test period this patient was in slight negative calcium balance.

X-rays showed involvement of all bones of the right half of the body, the right foot, upper and lower leg, entire right half of the pelvis, hand, arm and forearm, skull and mandible being implicated. Other than lesions in the left ilium, left hand, left half of the mandible, and base of the skull, the left half of the body was uninvolved.

On Feb. 17, 1940, biopsy was performed with removal in toto of a 3 by 2 cm. sized cyst from the anterolateral aspect of the right lower thigh. Upon incising the fascia lata it was obvious that there was complete alteration of the normal muscle, fascial and areolar tissue. There was almost complete replacement of muscle bellies by lobular masses of varying sizes with total disorganization of the normal fascial planes. The cyst was easily shelled out by blunt dissection during which there was a conspicuous absence of bleeding.

Pathologic report on the cyst wall stated that it consisted of fibrous tissue with a small amount of elastic tissue interspersed. The contents were described as gelatinous, mucoid, transparent, yellowish material with no evidence of cellular inclusion. The final opinion was that there was a close resemblance to a ganglion.

High thigh amputation was requested by the patient, but because of the technical difficulties of the fitting of a prosthesis, hip disarticulation or knee fusion was all that could be considered. On April 16, 1940, a Hibbs' arthrodesis of the right knee was done despite the prediction that little hope for bony union was entertained after consideration of the reduced amount of cortical bone. To date there has been no clinical or x-ray evidence of osseous union.

A second biopsy was done on Aug. 3, 1940, at which time two additional soft tissue tumors 3 by 4.5 cm. were shelled out and a piece of cortical and medullary bone from the midportion of the femur obtained. The femoral shaft was found to be considerably enlarged and uniformly irregular. There was no evidence of cortical bone defects, but the cortex could be penetrated easily by a blunt instrument. Inspection of the medullary cavity revealed that there was complete replacement of normal cancellous bone by cystic masses of varying sizes resembling those encountered in the thigh. Small amounts of granular material were palpated which were probably the remnants of the bone trabeculae. Throughout the procedure, little or no bleeding was encountered. The microscopic diagnosis from a competent pathologist was an aberrant form of hyperparathyroidism.

CLINICAL FEATURES

1. *Age of Onset.*—As in the above case, the physician frequently is consulted because of mechanical difficulties when the patient is middle-aged or older. Severe cases in children are exceptions. The onset of the lesions before the age of 10 years followed by a long, protracted, benign course which extends over years is characteristic.

2. *Skin Pigmentation.*—While there was no evidence of skin pigmentation reported in any of Lichtenstein's eight cases, Albright placed particular emphasis upon this feature, believing it to be a cardinal clinical sign. Goldhamer also mentions an increase in the melanin content of the skin. While there is a suggestion of peripheral nerve distribution on the right chest wall of this case, the vertical paravertebral location on the left side disclaims any neurological relationship. The dermatological manifestations do not suggest the type of skin pigmentation seen in neurofibromatosis.

3. *Pain.*—Lichtenstein and others believe that pain is common, especially in the hip. This appears to be reasonable upon consideration of the marked femoral deformities with alterations in the femoral head and development of secondary acetabular arthritis demonstrable on the x-rays of this and other reported cases. Disregarding that pain, which can be explained on the basis of joint derangement and arthritis, a possible explanation may be found in the dull ache experienced by patients with Paget's disease. Cortical expansion is common to both, and the pain likewise may be of periosteal origin.

4. *Deformities.*—With a material reduction of cancellous bone and particularly in those instances where medullary bone is completely replaced by fibrous tissue throughout the diaphysis, deformities of bones of the lower extremities are to be expected. Since a small amount of cortex is sufficient to prevent changes in the small bones, gross malformations are encountered in the long bones and particularly the femur. Lateral and anterior bowing of the femur, coxa vara, genu valgum, and pes valgus are most often encountered. Any alteration in shape is secondary to stress and weight placed upon abnormal bone and is not an intrinsic part of the disease as seen in Ollier's disease where disturbances in epiphyseal plate development result in growth abnormalities. Shortening of the lower extremity may be extreme, although Freund and others have reported an increase in length of the involved leg.

5. *Fractures.*—While there was adequate trauma in this case and in other reports to explain the fractures of the femoral shaft, it is to be expected that pathologic fractures would be prevalent. It is remarkable that not more have been encountered in this case after consideration of the x-rays. While there are no reports of fractures in bones other than the femur, there seems to be no tendency to nonunion.

6. *Sexual Changes.*—Sexual precocity was an early and invariable manifestation in Albright's cases and in all other reports to which he refers except that of Campbell's. Freund's patients, who were at puberty or older, did not display similar changes, and there is no mention of precocious sexual development in recent years in the literature with the exception of Moehlig and Schreiber's report of a young male who had feminine breasts, puerile voice, absence of beard and axillary hair, and feminine distribution of pubic hair. Marked thickening of all the bones of the base of the skull is present in this case without alteration in primary or secondary sex characteristics.

7. *Subcutaneous Tumors.*—That this was a case of extreme severity with advanced lesions was evidenced by the presence of numerous masses of varying size lying in the subcutaneous tissues of the right thigh, lateral aspect of the right hip, both buttocks, and over the sacrum and lumbar spine. These tumors varied from 1 by 1 cm., to 8 by 10 cm. in size. They were firm, well encapsulated, freely movable, nontender, and

unattached to the skin. Arrangement was haphazard with no attempt at distribution along peripheral nerves, some crossing midline. In some instances these masses were immediately beneath the skin and superficial to the fascia. In addition there were innumerable similar lesions in the intermuscular fascial planes and in many instances imbedded directly in the muscle bellies to such an extent that there was almost complete replacement of the thigh musculature. Biopsies of the cysts on two occasions revealed similar microscopic findings identical with those of the cystic masses removed from the medullary canal of the femur.

Two explanations are suggested: (1) Biopsy revealed the cortex of the femur to be paper thin, and it is possible that a minute cortical defect may have existed with escape of medullary canal contents. The widespread distribution to the subcutaneous level, the encapsulated nature of the tumors, and the findings of an intact periosteum are incompatible with such an explanation. (2) As will be explained later, it is generally believed that this disease is based upon a congenital abnormality in fibrous tissue maturation and development.

X-RAYS

The characteristic location and appearance of the roentgenograms are the most valuable and important of all clinical or laboratory evidence. While most writers describe unilateral lesions, there seems to be no valid reason why such an arrangement should always exist. In severe cases, particularly in children, bilateral lesions are present, as reported by Albright. Involvement was predominantly unilateral in the patient reported here, but both ilia and hands were affected with suggestive areas of rarefaction in the long bones on the left side.

The roentgenograms characteristically exhibit multiple areas of decreased density involving the entire or major portion of the diaphysis, stopping at the epiphyseal plate in children and extending to the articular cartilage in adults. Partial involvement of the diaphysis of long bones is unusual in contradistinction to the findings in cases of giant-cell tumor, osteitis fibrosa cystica localizata, xanthomatosis, and Ollier's disease. Extension from articular cartilage to articular cartilage without permitting interspersion of areas of normal bone depends upon the age of the patient and the duration of the disease, rarely being encountered before puberty and consistently thereafter.

Scattered among the cystic lesions are areas of increased density. These are irregular, are variable in size and density, and assume haphazard patterns. The outlines of these areas are hazy and exhibit no reactive peripheral zone. There is a close resemblance to osteopoikilosis, the lesions in the os calcis being most suggestive.

The diaphysis is characteristically widened, and with severe involvement such increase may be great. These changes are understandable after consideration of the atrophy and thinning of the cortical bone. X-rays of bones in which fractures have occurred reveal adequate callus of periosteal origin with evidence of periosteal new bone being present without exception. There is no evidence of interruption of continuity of the cortical bone.

The areas of rarefaction are of varying size, and in many instances possess indefinite outlines coalescing in such a manner that a large section of the bone appears to be generally decalcified. Trabeculation is not a prominent feature, but occasionally thin, delicate trabeculae are noted. These thin, indefinite trabeculations bear little resemblance to those seen in giant-cell tumor or localized osteitis fibrosis cystica.

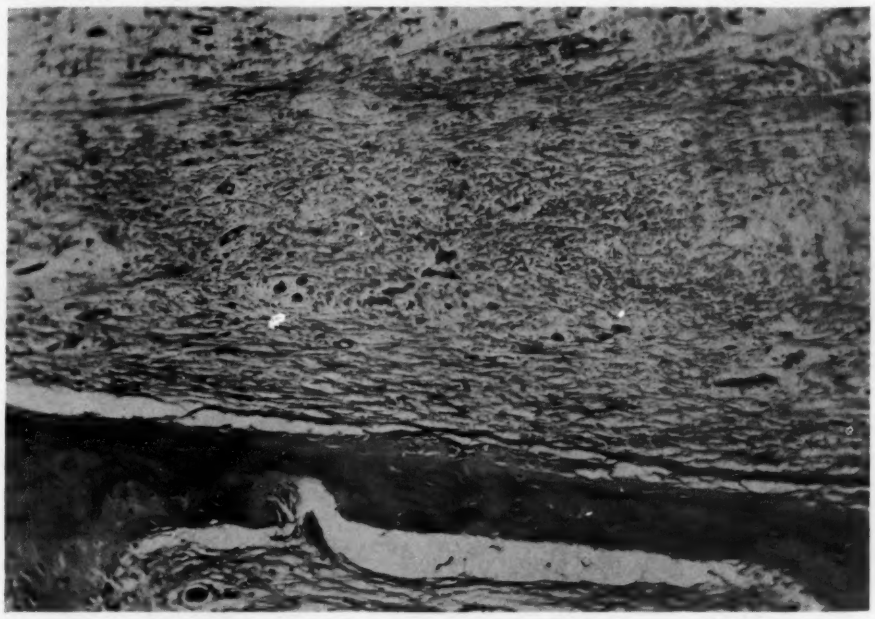


Fig. 2.—Cortical bone is atrophic but without a break in continuity. Notice the tremendous thickening of the periosteum with marked increase in connective tissue overlying the periosteum. Endosteum is not discernible.

The femur is the bone most commonly involved, followed in order by the pelvis, tibia, humerus, radius, ulna, small bones of the hands and feet, and skull.

With extension of the cystic areas into the femoral head and condyles, deformities secondary to weight-bearing are common. Coxa vara, varus deformities of the femoral shaft, genu valgus, and anterior bowing of the tibia are encountered. Contralateral bones which are not involved maintain normal density; this is an important diagnostic point when considering hyperparathyroidism. Roentgenograms of some of the published cases reveal sclerosis, particularly of the tibia.

In interpreting the x-rays of polyostotic fibrous dysplasia, it is paramount to remember that the individual lesions of this disease are nonspecific from a pathologic viewpoint and that analysis of x-rays con-

Fig. 3.

Fig. 4.

Figs. 3 and 4.—There is almost complete replacement of medullary bone trabeculae by fibrous tissue. Note the uneven staining of the bone. There is no evidence of giant cells or cartilage. The rich blood supply is clearly visible.

fined to a limited area may lead to erroneous conclusions. It is the unilateral distribution with involvement of the entire diaphysis that suggests the diagnosis rather than the appearance of any localized area.

PATHOLOGY

Gross Pathology.—The subcutaneous tumor masses at biopsy were found to be grayish, glistening cysts with translucent walls. These were easily shelled out of the subcutaneous tissue and fascial planes by blunt dissection. The size varied from several millimeters to 8 to 10 cm. in diameter. There was actual contact by the cysts with the periosteum at many points. The contents of these cysts was a thick, gelatinous, mucinous material closely resembling the contents of a ganglion.

The cortical bone was paper thin and yielded easily to a blunt instrument. There was marked alteration in the appearance of the periosteum, being 2 to 4 mm. thick, boggy, and indurated. The normal glistening appearance was replaced by a dull, whitish, lusterless tissue somewhat

Fig. 5.—Both hands are involved, the right more than the left. The right hand shows all bones affected along with expansion of the metacarpals.

resembling scar tissue. Attempts to elevate the periosteum revealed it to be abnormally friable and without the usual periosteal bleeding. Raising of a trap door of cortical bone disclosed the medullary canal to be completely replaced by gelatinous tissue closely resembling the cystic material encountered in the soft tissues of the thigh.

It is now generally appreciated that the microscopic picture of fibrous tissue replacement of medullary bone with absorption of bone trabeculae is not a specific response to any single etiological factor or disease. Osteitis fibrosa is seen in hyperparathyroidism, localized osteitis fibrosa

cystica, neurofibromatosis, callus following fracture, Paget's disease, osteomalacia, rickets, and chronic inflammatory diseases of bone.

Jaffe and Lichtenstein, who have had an opportunity to examine the most pathologic material, have described thinning of the cortical bone which they believe is due partially to absorption but chiefly to erosion of the endosteal surface by the proliferating fibrous tissue. There have been no descriptions of endosteal new bone formation, and this agrees with the microscopic findings of our biopsies. There was no evidence of penetration of the cortex by fibrous tissue in these specimens.

Fig. 6.—The location of lesions throughout the entire length of the femur is characteristic. The shaft is moderately expanded and the cortex reduced throughout. The defect in the cortex on the lateral aspect is the site of biopsy.

There has been almost complete replacement of medullary bone by fibrous tissue in this case and in the photomicrographs reproduced by Jaffe and Lichtenstein. Some sections (Figs. 3 and 4) reveal considerable replacement, while elsewhere bone trabeculae show less absorption. The fibrous tissue encountered differs in no way from that seen in osteitis fibrosa in other lesions. The bone trabeculae appeared to possess no definite pattern and stained poorly. Osteoclasts were not seen. There was no evidence of giant cells or cartilage. Vascularity was surprisingly rich.

DIAGNOSTIC AIDS

The values for blood serum phosphorus and calcium in this case and in all those reported have been within normal limits. There have been a few instances where the calcium values approached the upper limits of normal without apparent significance.

The phosphatase level has shown slight elevation on occasion in this case. Freund and Lichtenstein reported cases showing phosphatase elevation as high as thirty-two units. Such elevation has been adequately proved to depend upon new bone production. In polyostotic fibrous dysplasia there is some capacity for new bone formation and, as has been shown on x-ray, this is chiefly periosteal.

Fig. 7.—The entire right half of the pelvis, all of the sacrum, and the crest of the left ilium are involved. Absence of lesions in the lumbar spine is notable.

PATHOGENESIS

It is obvious that we are dealing with an inherent disorder of fibrous tissue rather than alterations in bone secondary to extraosseous factors. Those cases which have been carefully followed date the onset of the disease to childhood or earlier. Albright's youngest case was 3½ years of age. Certainly the characteristic onset before the age of 10 years followed by a long, chronic, slowly progressive course strongly suggests congenital etiology. There are few skeletal lesions whose duration extends over decades and whose character is essentially benign despite

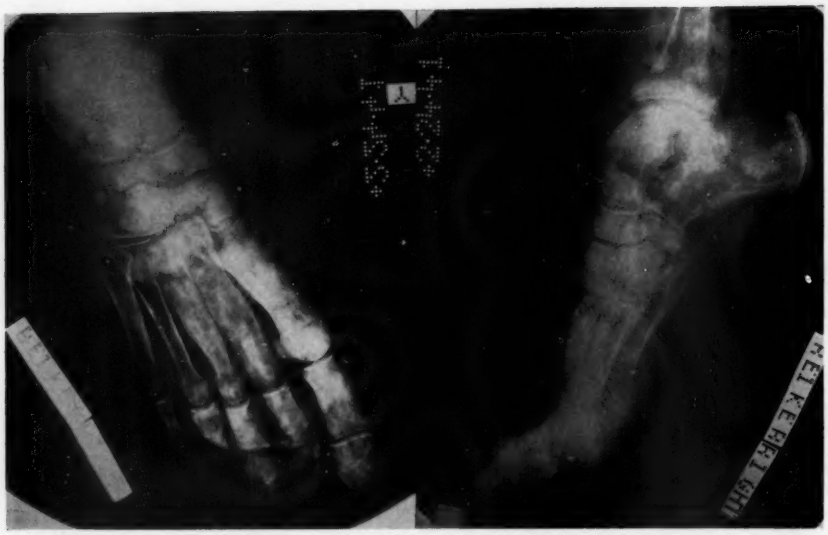


Fig. 8.—Expansion of the metatarsals and phalanges more marked than in the hand with maximum changes to be noted in the medial portion of the foot. Notice the well-defined areas of sclerosis in the os calcis and lower ends of tibia and fibula.

Fig. 9.—The knee region illustrates well the combination of areas of increased density intermingled with the cystic lesions. There is no evidence of the epiphyseal plate acting as a barrier, extension to subchondral level being evident.

concomitant advanced pathologic changes that can be accounted for other than on a congenital developmental abnormality. The presence of numerous cystic masses outside bone which possess no clinical or microscopic evidence of malignancy seem to be best explained upon a congenital aberration of primitive fibrous tissue. The similar gross and microscopic resemblance between the fascial and osseous lesions would indicate a common genesis. The unilateral distribution of the lesions precludes the possibility of endocrine or hormone etiology, as does the presence of normal, unaffected bones on the opposite side.

A. *B.*

Fig. 10.—Thickening of the basilar portions of the occipital, temporal, and sphenoidal and frontal bones is characteristic. Notice the encroachment on the sella turcica. Involvement of both sides of the mandible is discernible.

DIFFERENTIAL DIAGNOSIS

1. *Hyperparathyroidism.*—The superficial resemblance of the roentgenograms of the lesions of polyostotic fibrous dysplasia to hyperparathyroidism has created confusion, and in most instances has been described under hyperparathyroidism, as evidenced by numerous reports of surgical exploration of the parathyroid glands without encountering adenomas.

Before the establishment of hyperparathyroidism as a distinct clinical entity it was appreciated by Freund, Hunter, and Turnbull and Jaffe that there were cases of cystic bone lesions which were not explainable on an endocrine imbalance. This fact unfortunately is not generally appreciated today despite recent authoritative articles.

As has been emphasized already, if x-ray examination is confined to a single bone or to a portion of an extremity or if the diagnosis has been

made on biopsy alone, serious errors will occur. The microscopic pathology of hyperparathyroidism and Ollier's disease is closely similar but nonspecific, and it is obvious that limited x-ray examination would result in roentgenograms which would be confusing. Polyostotic fibrous dysplasia with its onset at or before puberty, long, protracted course, normal blood calcium and phosphorus values, and characteristic unilateral distribution of lesions creates a well-defined syndrome. The presence of bones of normal contour and density on the unaffected side in a patient with multiple cystic lesions along with areas of skin pigmentation and multiple subcutaneous nodules of varying sizes should be helpful in ruling out generalized osteitis fibrosa cystica.

Fig. 11.—The entire lengths of both tibia and fibula are implicated. There is only moderate bowing despite considerable loss of cortical bone. Notice that there are no areas of normal bone existent.

2. *Ollier's Disease.*—Dyschondroplasia with its resultant deformities presents x-rays so characteristic that differentiation should not be difficult and biopsy would appear to be rarely necessary. The lesion is primarily localized to the epiphyseal plate in Ollier's disease, and as expected, the metaphysis and juxtaepiphyseal areas are the sites of maximum pathologic changes. Unlike polyostotic fibrous dysplasia, the

shaft or center of the diaphysis is usually uninvolved. Clubbing of the metaphysis with longitudinal areas of sclerosis alternating with areas of decreased density are in contrast to the uniform expansion of the entire shaft as seen in fibrous dysplasia. Severe deformities subsequent to alterations in the epiphyseal cartilage are more common in Ollier's disease.

PROGNOSIS AND TREATMENT

The prognosis of polyostotic fibrous dysplasia for normal life expectancy apparently is excellent. Deformity and disability, especially of the lower extremities, is common, and while these patients may continue to be active for many years without discomfort, they may ultimately seek medical aid for mechanical difficulties.

A. *B.*

Fig. 12.—While the entire humerus, radius, and ulna are involved, the cystic appearance is less marked, particularly in the ulna. Gross deformities are nonexistent in contrast to the lower extremities.

Up to the present there has been no report of nonunion following a fracture nor any evidence on a clinical or microscopic basis for malignant transformation of any of these lesions.

While there have been alterations in secondary sex characteristics in young female patients, adult patients of both sexes have not been noteworthy in this respect.

Lichtenstein believes that the phosphatase level is of value in estimating surgical prognosis and that little evidence of new bone formation exists when phosphatase values are within normal limits. The extent of involvement, the amount of cortical expansion, and residual bone cortex should determine the patient's fitness for surgical procedures rather than the phosphatase level. Alterations in other bones with abortive

attempts at new bone formation may elevate the phosphatase level and lull the surgeon into a false sense of security. Surgery on any bone which is severely involved should be considered only as a final resort. It is probable that new bone formation is more active in young patients as all reported fractures in this age group healed promptly. Amputation or the employment of braces in severe deformities of the lower extremities would appear to be more satisfactory than attempts at arthrodesis or surgical correction of deformities.

SUMMARY

1. Polyostotic fibrous dysplasia is a definite clinical entity with characteristic roentgenograms.

2. Differentiation from hyperparathyroidism is essential in view of more favorable prognosis and nonsurgical management.

3. Additional evidence indicating origin from fibrous tissue dysplasia is presented.

4. Reconstructive surgery on involved bones does not appear to be warranted.

I am indebted to Dr. Joseph A. Freiberg, of the Cincinnati General Hospital, for assistance in preparing this article.

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THE SCALENUS ANTICUS FACTOR IN CONGENITAL TORTICOLLIS

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CONGENITAL torticollis, although known for centuries, remains a therapeutic enigma at the present and the multiplicity of operative procedures advocated for this entity serves as a mute witness to this fact. Torticollis, in general, is characterized by an involvement of the sternomastoid muscle, although at times other cervical muscles are involved, in which the muscle undergoes a contraction resulting in its overaction and thereby causing a deformity. This condition is unilateral in the majority of cases; however, a bilateral type does occur rarely. Recently, it has been my experience while operating upon two successive cases of congenital torticollis, to encounter a factor not heretofore mentioned; namely, the scalenus anticus muscle as being partly responsible for the deformity. This observation was first noticed during the course of the operation and when it was seen again in a few weeks, its importance was emphasized. Since these two cases were seen, a third case has presented a similar picture.

Because the discussion of the role of the scalenus anticus muscle is limited to certain types of torticollis, and wishing to avoid confusion, a classification of torticollis in general is presented.

TORTICOLLIS

1. *Acquired Torticollis.*—This is the commonest form of torticollis and is usually termed a "stiff neck." It is a myositis of the sternomastoid, occasionally the trapezius, due to exposure or changes in temperature. Although self-limited, heat therapy is of benefit.

2. *Congenital Torticollis.*—This is subdivided into three groups as follows:

A. PRIMARY CONGENITAL TORTICOLLIS.[1]—This type is invariably caused by an embryonic defect and is present long before delivery. It is due to one of the following: (1) synostosis of atlas and axis, (2) fusion of atlas and occiput, (3) malformation of cervical vertebrae, or (4) cervical rib.

B. SECONDARY CONGENITAL TORTICOLLIS.—This type fails to reveal any basic anatomical deficiency but definitely antedates birth and is present at time of delivery. There is no adequate explanation of the phenomenon, but it has been theorized that an abnormal position of the fetal head in utero may be the reason.

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C. Parturitional Torticollis (Cases Occurring During Delivery).—This group is included under congenital torticollis because of custom, but it is really a distinct class in itself. It is the commonest form of congenital torticollis and is more amenable to surgical therapy than is any other type. The term parturitional is suggested because this type does not occur before delivery but is noticed a few hours to a few weeks after delivery. The pathologic lesions may be classified as follows: (1) rupture of the sternomastoid muscle, (2) hematoma of the sternomastoid muscle with subsequent fibrosis, and (3) combinations of the rupture and hematoma. This type, parturitional torticollis, is the one referred to as being affected by the scalenus anticus muscle.

3. *Functional Torticollis.*—A peculiar type that does not reveal any organic muscular spasm or contraction. It may be necessary to immobilize the neck by means of a plaster of Paris jacket or a corrective brace. A satisfactory brace is one described below (Fig. 2). The prognosis for complete cure is excellent.

4. *Spasmodic Torticollis.*—This form is characterized by clonic spasms of the sternomastoid plus other cervical muscles, particularly those in the suboccipital triangle. An encephalitis is usually considered to be an initiating factor. The prognosis is not favorable as to cure. Operations on the spinal accessory nerve as well as the fifth, sixth, and seventh cervical nerves and various myotomies have been advocated.

According to the above classification, there are many types of torticollis of which the acute acquired torticollis or "stiff neck" is the most frequent. However, this type is of slight clinical and surgical significance because it is very transitory. The next commonest type is parturitional torticollis which heretofore has been termed congenital torticollis. When these patients are operated upon, it has been observed that the sternomastoid muscle per se is shortened and contains a preponderance of scar tissue, so much so that large patches of blanched fibrous tissue replace the normal muscle tissue. Adhesions, quite dense at times, exist between the capsule of the muscle and the muscle proper. Other soft parts of the neck may be adaptively shortened. These changes impress one as being due to a fibrous myositis and perimyositis, and with a history of occurring shortly after delivery, it is reasonable to assume that it is of traumatic origin. The usually employed operative procedure to correct this lesion is section of the sternomastoid muscle and all adhesive bands. This procedure has met with both success and failure, some deformities being overcome while others persisted. The explanation for this is not clear, but from the case histories described below one will observe that the scalenus anticus muscle may have played a cardinal role in perpetuating the deformity in those cases that did not respond to sternomastoid myotomy alone.

Case 1.—Master G. M., 14-year-old white male (Fig. 1), was admitted to the Touro Infirmary on April 21, 1938, with a chief complaint of "crooked neck."

This complaint had been present since infancy. The physical examination showed a marked inclination of the head toward the left shoulder, the chin pointing toward the right. The right side of the face was larger than the left. The sternomastoid muscle on the left was very spastic and its anterior border on touch seemed as if it was a taut rope. The motion of the head was very limited in all directions and the deformity could not be corrected either actively or passively. The scapula on the affected side was more elevated than the other. The remainder of the physical and laboratory examinations were essentially negative. The x-rays

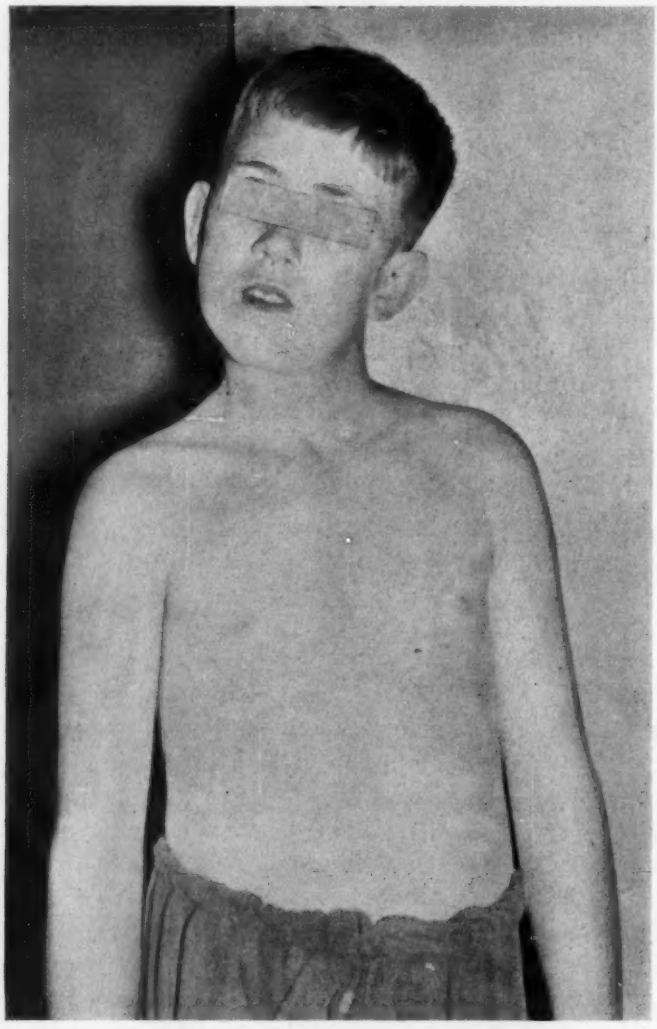

Fig. 1.—Case 1, before operation.

of the head and neck did not reveal any osseous deformities. Parturitional torticollis was considered the most likely diagnosis. Operation was performed on April 22, 1938, under a general anesthetic. A curved incision, one inch above the left to just beyond the posterior border, was made. The incision extended through the skin. The flap, the subcutaneous tissue, and platysma muscle were dissected upward en masse. It was necessary to ligate the external jugular vein. The anterior capsule of the sternomastoid was incised and the sternal and clavicular heads of

the muscle exposed. The two muscle heads were dissected free from the posterior muscle capsule and severed in an oblique direction. No bleeding was encountered in the muscle proper. The posterior muscle sheath was then divided. An unsterile assistant now placed the head in overcorrection and it was noted that there was some inhibitory factor preventing overcorrection. The wound was palpated and a tense, thick, spastic mass was palpable. This proved to be the scalenus

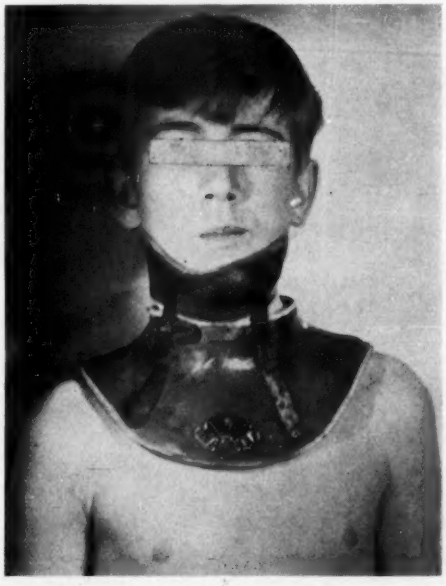

Fig. 2.—Case 1, after operation and after body cast has been removed. Patient wearing postoperative brace of author's design.

Fig. 3.—Case 1, six months after operation. Compare with Fig. 1.

anticus muscle. The transverse colli artery was retracted, the prescalenus fat was dissected, and the muscle exposed. The phrenic nerve was visualized on the anterior surface of the muscle and retracted medially. The sixth and seventh cervical nerves were seen lateral to the muscle. The muscle appeared to be tense and hypertrophied. An anterior scaleniotomy was done following which the unsterile assistant was able to place the head in extreme overcorrection. With the head in this position, digital palpation failed to reveal any further constricting structures. The wound was closed in layers.

The patient's head was then placed in overcorrection and a body cast applied from waist to forehead. The patient left the operating room in good condition. He was discharged from the hospital four days later; the maximum temperature during his hospital stay was 99° F. In six weeks the cast was removed and a special correction brace was applied (Fig. 2). Corrective exercises were also instituted. A very satisfactory result has occurred (Fig. 3). The patient is able to swim and play ball for the first time in his life.

Fig. 4.—Case 2, before operation.

CASE 2.—Master E. H., 5-year-old white male, was admitted to the Touro Infirmary on June 1, 1938, with a diagnosis of parturitional torticollis. The patient's head was inclined toward the right, which was first noted two weeks after delivery. The child had been a breech presentation and was delivered by version and extraction with forceps on the aftercoming head. The deformity became more pronounced with time. The head was inclined toward the right at about a 30° angle. Extension and flexion of the head to the left were inhibited. The right half of the face was slightly smaller than the left; the scapulae were on an equal level. X-rays of the head and neck were negative for osseous deformity. The same operative procedure was performed as in Case 1 and again it was noted that some factor inhibited overcorrection. Again, further examination revealed a tense, hypertrophied scalenus anticus muscle, which, when sectioned, allowed liberal overcorrection. A body cast was applied from the waistline to the forehead. After six weeks, the cast was removed and a brace was applied and corrective exercises were instituted. In this case also an excellent result was obtained (Figs. 4 and 5).

CASE 3.—A. C., 15-year-old white male, was admitted to the Touro Infirmary on Jan. 8, 1939, with a diagnosis of parturitional torticollis. Details of the patient's delivery were not available, but the deformity had been present since birth. The

head was turned to the right and the chin pointed downward. A hemiatrophy of the right half of the face was present. The operation as described in Case 1 was performed and a hypertrophy of the scalenus anticus muscle was present. However, it was necessary to expose this muscle before concluding it was hypertrophied for palpation was not as definitely indicative as in the above two cases. A microscopic examination of the muscle revealed large amounts of fibrous connective tissue. The postoperative course was uneventful; a body cast was worn for six weeks followed by corrective exercises and a brace for six months. At the time of operation, the patient was a messenger boy and had obtained this position only through influence. Since operation, he has held better positions in industrial plants and has passed physical examinations to obtain the two positions without any difficulty (Fig. 6).

Fig. 5.—Case 2, six months after operation. Compare with Fig. 4.

At the operation in Case 1 it was evident that the scalenus anticus muscle played a role in maintaining the deformity, and when a short time later a second case was observed with a similar pathologic picture, it suggested that the condition occurs not infrequently. The third case was noted because my former experience made me determined to expose the scalenus anticus muscle routinely in this type of operation. The modus operandi of the scalenus anticus factor was not clear at first, but when the anatomy and function of this muscle was studied, the probable mechanism becomes evident.

Morris[2] described the function of the scalenus anticus as follows: "With the thorax fixed, the scalene muscles bind the neck to the side and slightly forward and turn it slightly towards the opposite side." Deaver[3] stated: "The anterior scalene muscle, when acting from its point of origin, will raise the first rib, but if the rib be fixed, the muscle acting from below will flex the lower cervical vertebrae, at the same time slightly rotating these vertebrae." The scalenus anticus muscle arises from the anterior tubercle of the transverse process of the third,

fourth, fifth, and sixth cervical vertebrae and is inserted into the tubercle on the inner border and under surface of the first rib in front of the groove for the subclavian artery. In parturitional torticollis in which there is fibrosis in the sternomastoid muscle and firm attachment of the muscle belly to its capsule, a shortening of the muscle occurs. Because of this, the head is depressed laterally toward the clavicle and first rib on the affected side. With the head in this position, the distance between the origin and attachment of the scalenus anticus muscle is likewise shortened. As the patient grows older and the scalenus anticus develops, it will be shortened in length but will be broader so it may appear hypertrophied. On the other hand there is also the

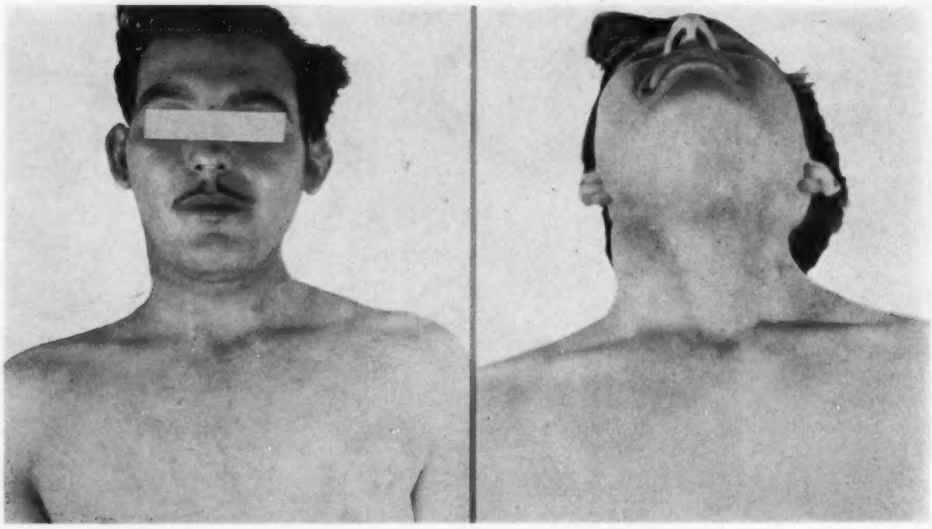

Fig. 6. Fig. 7.

Fig. 6.—Case 3, anteroposterior view one year following operation.
Fig. 7.—Case 3, head in hyperextension one year following operation.

possibility that the scalenus is hypertrophied because it also suffered a traumatic myositis at the time of delivery similar to that occurring in the sternomastoid. Although it cannot be considered as a primary etiological factor, it will act to maintain the deformity and can therefore be considered as a secondary etiological agent. If this chain of events is true, it is important that the scalenus anticus muscle be examined at operation in each case of torticollis. It is entirely plausible if the above hypothesis is accurate that the scalenus anticus factor may explain why sternomastoid myotomy is successful in some cases and fails in others.

However, a note of warning may be in order at this point. One should not indiscriminately sacrifice the muscles of the neck on the affected side for it is possible that the patient may be overcorrected and will then be more miserable than originally. If there is any doubt

as to whether or not the scalenus anticus is an etiological factor, it is safe to sacrifice it, for in no case herein reported did one note any post-operative inhibition of head movements. The results obtained have been excellent, and although I have no right to base conclusions on such a small series, I do consider it of importance and worthy of attention in the future.

SUMMARY

1. A classification of torticollis is presented.

2. The term parturitional torticollis is more accurate than congenital torticollis.

3. Three cases of congenital torticollis are presented wherein the scalenus anticus muscle appears to have played a role in maintaining the deformity.

4. A discussion of the modus operandi of the scalenus anticus factor in congenital torticollis is presented.

5. It is suggested that definite examination of the scalenus anticus muscle be made at the time of operation in all cases of torticollis.

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TWO CASES OF RAT-BITE FEVER

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RAT-BITE fever was known in India as long as 2,300 years ago.[1] In 1839, Wilcox described a case seen in his practice which typified the course produced by the infection. Modern literature reveals that the disease is known in practically every country of the world. The main agency of spread is the bite of wild rats, but several cases have been attributed to the bite of cats,[2] squirrels, weasels, pigs, and monkeys. The disease is known as sodoku, from the Japanese "*so*," rat; and "*doku*," poison.

The exact etiology of rat-bite fever was discovered by Futaki and his associates in 1916. They called the organisms *Spirochaetae morsus muris*. It is a spirillum 3 by 4 U. long, approximately 0.2 U. thick, with pointed ends, carrying one or more flagella. The organism has a very rapid darting, to-and-fro motion, with a spinning movement around the long axis. It has never been cultivated in artificial media. The organism can be identified by Giemsa or Wright stain and dark-field examination. The material should be obtained from venous blood and cultured by mouse inoculation. The procedure is as follows: Two cubic centimeters of blood from an infected patient is injected into the peritoneal cavity of a mouse. An incubation period of from fourteen to twenty days is allowed to elapse. At the end of this time, the cardiac blood of the mouse is examined for the organisms.

In pathogenicity the *Spirillum morsus muris* bears a resemblance to *Spirochaeta pallida* and like it is destroyed by arsenical drugs. Where the skin is perforated by the rat bite, usually on the hands, arms, or lower extremities, a lesion develops presenting the gross appearance of a granuloma without evidence of suppuration.[3] The tissue sections of the wound at the point of entrance, when examined under the microscope, reveal necrosis of the epithelium and dense round-cell infiltration of the corium. The parenchymatous organs present a generalized picture of toxemia as might be expected from a continued intermittent febrile disease. Hyperplastic dilated sinuses and hyperemia of the suprarenal glands and of the cortex of the spleen are also found. The central arteries of the malpighian bodies in the spleen develop hyaline degeneration.

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The case histories of two patients treated at Grasslands Hospital are presented:

CASE 1.—This patient was a 4½-month-old white male. On Nov. 30, 1938, while sitting in a baby carriage on the front porch of his home, he was bitten on the third and fourth fingers of his left hand by a rat. Merthiolate was applied immediately to the wounds without attempt at cauterization.

Fig. 1.—Case 1. Rat-bite wound on the third and fourth left digits.

On Dec. 6, 1938, the child was admitted to the surgical service because of inflammatory lesions on the fingers. At this time, the wounds appeared edematous, indurated, and dark bluish in color with all signs of inflammation. Direct smears and cultures of the lesions were negative for organisms. On admission the temperature was 100.2° but subsequently rose to 101.2°. It was relapsing in character with afebrile periods of four to five days. The Kline and Wassermann reactions were negative. The white blood count was 13,000. On the eighth hospital day the patient became lethargic, was nauseated, vomited, and had diarrhea. The red blood count was 2,900,000 as compared to 4,500,000 on admission. Treatment consisted of blood transfusions, parenteral fluids, and symptomatic therapy. On Dec. 9, 1938, blood cultures were taken and mice inoculated with venous blood. The *Spirilla morsus muris* were isolated on the twentieth day. Immediately, 0.2 Gm. of neoarsphenamine were given intravenously. This resulted in eradication of general symptoms, return of temperature to 98.8° within twenty-four hours, and healing of the primary lesions within four days.

The patient was discharged on Dec. 21, 1938, as recovered. He has visited our follow-up clinic periodically. On Jan. 10, 1939, the child was given another therapeutic injection of 0.2 Gm. of neoarsphenamine intravenously without untoward reaction. On Nov. 4, 1940, he was asymptomatic and had gained eleven pounds in weight. No scars were present at the site of the original lesions and function of the fingers was excellent. The Kline test was negative.

CASE 2.—This patient was a well-developed, white, 13-year-old female admitted to the Pediatric Service and treated by that department. On Dec. 15, 1938, while playing at a garbage dump, she was bitten on the left wrist by a rat. It is interesting to comment that this girl lived in the same neighborhood as the infant of

Case 1. The emergency treatment consisted of cauterization and tetanus antitoxin. Two days later, local signs of inflammation with lymphadenitis appeared. These subsided in forty-eight hours. The patient remained asymptomatic until the seventeenth day when she became nauseated, vomited, and suffered from headache, malaise,

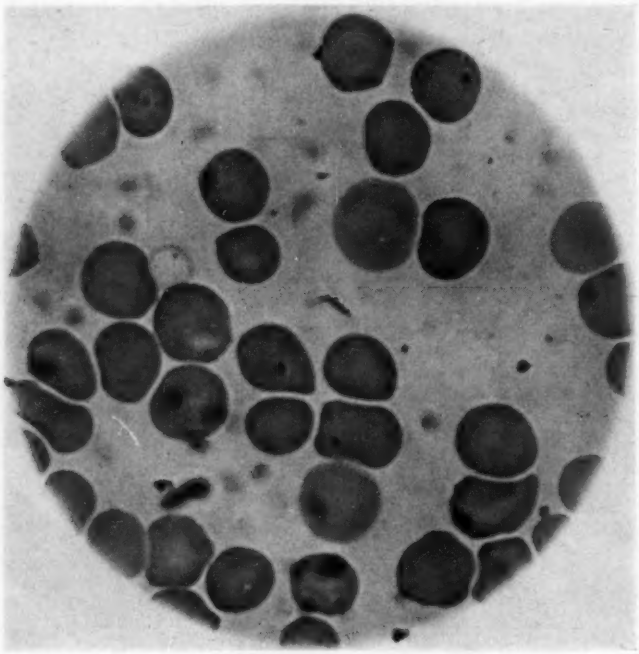

Fig. 2.—*Spirilla morsus muris* isolated from mouse inoculation (from blood of patient in Case 2).

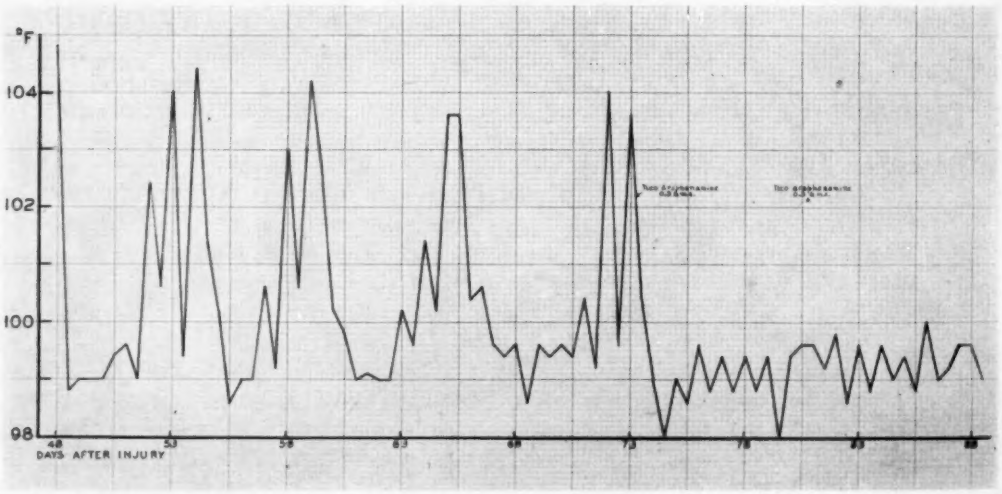

Fig. 3.—Temperature course of patient in Case 2. Injections of neoarsphenamine indicated on chart.

lethargy, and generalized muscular pains. At this time she was admitted to the hospital. Paroxysms of chills and fever recurred at five-day intervals. On the thirty-second day a maculoerythematous rash appeared.

The significant laboratory findings were leucocytosis of 13,000; hemoglobin, 12 Gm.; and red blood cells, 4,690,000. On admission the Kline test was doubtful, but twenty-four days later it became positive. During the temperature peak the examination of the venous blood on direct smear revealed *Spirilla morsus muris*. This was confirmed by mouse inoculation.

On Feb. 2, 1939, 0.3 Gm. of neoarsphenamine was administered intravenously. The child immediately became asymptomatic and afebrile. On Feb. 10, 1939, 0.3 Gm. of neoarsphenamine was again given intravenously. She was discharged on Feb. 18, 1939, as recovered. When seen in the follow-up clinic she had gained weight and had been asymptomatic since discharge. Primary lesions had caused no scars. The last visit was on Nov. 8, 1940, at which time the Kline test was still positive.

SUMMARY

Rat-bite fever is a rare disease in the United States. These were the first cases seen at Grasslands Hospital, and only 91 cases have been reported in the American literature. Nevertheless, it is a disease which may be diagnosed without unusual difficulty and may be successfully treated. The Kline test is positive in 50 to 60 per cent of cases during the acute phase of the infection but will eventually become negative.[4]

The clinical course[5] is characterized by development of an inflammatory lesion at the site of injury followed by the onset of fever with recurrent paroxysms of chills and fever, muscular aches and pains, cutaneous eruption, lymphadenitis and lymphangitis, neutrophilic leucocytosis, and varying degrees of prostration, and responds promptly to the administration of arsphenamine (and similar drugs) intravenously.

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INTESTINAL OBSTRUCTION AS A PHASE OF CARCINOMA OF THE CERVIX*

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NEOPLASTIC obstruction of the intestine, though long recognized, is an apparently neglected phase of cervical carcinoma. Incidental allusions to this feature of the disease are found in the literature, but factual elaboration of the subject has seldom been attempted. Only a minority of cases suitable for operative relief reach the surgeon, and the significance of incipient low-grade obstruction seems to be generally overlooked. The present communication offers relevant information obtained from a review of autopsy material at Charity Hospital of Louisiana at New Orleans.

During the eleven-year period ending Jan. 1, 1941, 74 cases of squamous-cell carcinoma of the cervix came to necropsy in this institution. Adenocarcinomas are excluded from this study. In 9 of these cases a diagnosis of intestinal obstruction had been entertained clinically, or had actually been confirmed, and post-mortem examination in each instance disclosed neoplastic extension to the bowel with definite reduction of its caliber. The incidence of intestinal obstruction in the autopsied material of cervical carcinoma is thus 12.1 per cent, which agrees with the figures previously reported by one of us (B. P.) in a similar series.

In these 9 cases three portions of the bowel showed neoplastic involvement which eventuated in obstruction: The ileum was affected in 3, the sigmoid in 1, and the rectum in 5. A double obstruction was present in 3 cases. The pathogenesis and mechanism of obstruction were of several types (Table I), but in all instances the degree of constriction was severe, since the study included only those with symptoms of obstruction.

In only 1 case (Case 8) was the obstruction complete. In this instance an annular metastasis to the ileum was located 20 cm. from the ileocecal valve and was so bulky that it was palpable through the abdominal wall in the right lower quadrant. A second ileal lesion (Case 5) occurred in a dependent loop of bowel attached to a tumor mass in the cul-de-sac of Douglas. Marked stenosis of the ileum resulting from the cancerous infiltration and fecal impaction produced functionally complete obstruction terminating in perforation of the gut and peritonitis. The third ileal lesion (Case 7) was identical except that rupture took place into the vagina and an ileovaginal fistula was thus created.

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In Case 6 a serosal implant had penetrated through the wall of the sigmoid, and after fungating internally had caused marked attenuation of the lumen. In Case 9 the ampullary portion of the rectum was functionally obliterated by pressure of a large carcinomatous mass growing diffusely in the pelvis. In Case 3 the same area was narrowed to a diameter of 2 cm. by intramural proliferation of an invading neoplasm.

TABLE I

TYPES OF INTESTINAL OBSTRUCTION IN CARCINOMA OF THE CERVIX

PATHOGENESIS	ROUTE OF DISSEMINATION	MECHANISM	EXAMPLE
Spread in the pelvis (I)	Infiltration of contiguous structures	1. Encirclement of the rectum	Cases 1, 3, and 4
		2. Compression of the rectum by a large pelvic tumor	Case 9
		3. Fungation of neoplasm into rectal lumen	Case 2
	Invasion of peritoneum	4. Stenosis of dependent loop of ileum	Cases 5 and 7
	Peritoneal seeding	5. Bulky growth of serosal implants on the sigmoid	Case 6
Metastases (II)	Blood stream	6. Isolated metastasis to small intestine producing constriction	Case 8
	Lymphatics	7. Infarction of bowel due to pressure on vessels by large mesenteric nodes	Case A35-359

In 3 other rectal strictures (Cases 1, 2, and 4), in which the residual lumen varied from 1 to 1.5 cm. in diameter, the principal area of involvement was characteristically at the level of the portio. In all 3 cases the lower edge of the constriction had been palpable clinically 5, 8, and 10 cm. respectively from the anus. Carcinomatous infiltration in the rectovaginal septum and the uterosacral ligaments completely encircled the rectum, involving the muscularis but not the mucosa. Rectal strictures of this type were also present in Cases 5 and 7 in addition to the ileal stenosis already described. In Case 9 obstruction at the same site (rectum) had been produced at different times by two distinct etiologic agents. The pressure of a pelvic abscess secondary to infection in the cervical growth had first rendered the rectum essentially impervious, and ten months later (three months before death) the rectum was again found blocked, this time by an extrinsic tumor.

A type of obstructive infarction which did not occur in the series of cases reported in this paper is illustrated by the following case history:

S. S. (A35-359), a colored woman, 65 years of age, was seen in August, 1934, with a mass in the cervix. The uterus was curetted and adenoacanthoma was found, which was treated by both radium and x-ray therapy. In February, 1935, a subcutaneous metastasis in the thigh was excised and clearly exhibited the structure of squamous carcinoma. The patient died a month later. Seeding of the peritoneum was found at autopsy; mesenteric nodes had produced compression and thrombosis of the mesenteric vessels with infarction and perforation of the small intestine.

TABLE II

CARCINOMA OF THE CERVIX WITH INTESTINAL OBSTRUCTION

NO.	COLOR AGE STAGE FIRST ADMISSION	PERIOD OF OBSERVATION PRIOR TO OBSTRUCTION	SYMPTOMS OF OBSTRUCTION	MEASURES FOR RELIEF OF OBSTRUCTION	LOCATION AND MECHANISM OF OBSTRUCTION	SURVIVAL AFTER OBSTRUCTION	MAIN CAUSES OF DEATH	EXTENT OF TUMOR INVOLVEMENT
1	W 53 IV	None	Progressive, severe, intermittent, crampy, colicky pains with vomiting and abdominal distention of 2 wk. duration	Rectal tube; sigmoid colostomy	Rectum stricture 10 cm. from anus	Postoperative death	Intestinal obstruction	Diffuse invasion of pelvis and peritoneal dissemination
2	C 25 II	6 mo.	Abdominal pain, distention and severe dyschesia	Conservative	Rectum stricture 5 cm. from anus	5 mo.	Uremia	Diffuse infiltration of pelvis and bladder
3	C 54 IV	None	Abdominal distention, vomiting, loss of weight, anorexia and intermittent abdominal pain of 3 wk. duration	Repeated enemas; sigmoid colostomy	Rectum mass 5 cm. from anus	5 days	Intestinal obstruction; postoperative peritonitis	Tumor in rectum and parametria
4	C 36 II	8 mo.	Abdominal pain, generalized	Conservative	Rectum stricture 8 cm. from anus	3 wk.	Endometritis, sepsis	Perirectal, vaginal, uterine involvement; pelvic and retroperitoneal nodes

5	W 45 III	10 mo.	Severe constipation and vomiting for 4 wk.; abdominal distention, no bowel movements for 3 days	Conservative	Rectum stricture; lower ileal stenosis	6 wk.	Intestinal obstruction, ileal perforation and peritonitis	Diffuse infiltration of pelvis, peritoneal dissemination, metastasis to umbilicus and pelvic nodes
6	W 52 IV	None	Lower abdominal pain for 6 months; intermittent colicky abdominal pain, nausea, vomiting, and anorexia and abdominal distention for 3 mo.	Conservative	Sigmoid adhered to uterus; nodule protruding 2 cm. into lumen	7 mo.	Carcinomatosis	Tumor in sigmoid, uterus, vagina, bladder, peritoneum, liver, stomach, lungs, pericardium
7	W 58 III	16 mo.	Abdominal pain; pain in rectum and diarrhea for a few days	Conservative	Rectum stricture; mass encircling rectum 6 cm. from anus; stenosis of ileum	2 mo.	Intestinal obstruction, peritonitis	Perirectal, bladder, and ileal involvement
8	C 69 IV	None	Colicky pains in the abdomen with nausea and vomiting of 3 mo. duration	Resection of ileum	Occlusion of ileum 20 cm. above cecum	2 wk.	Intestinal obstruction, peritonitis	Tumor in ileum, uterus, tubes and ovaries; metastasis to liver
9	W 40 III	None	First admission; crampy abdominal pain, nausea and vomiting	Colpotomy; 250 c.c. of pus drained	Rectum, extrinsic pressure by pelvic abscess	3 mo.	Uremia, anemia, sepsis	Perirectal, bladder, and vaginal involvement; peritoneal dissemination; pelvic and iliac nodes
		10 mo.	Second admission; progressive rectal pain, marked dyschesia	Conservative	Rectum, extrinsic compression by tumor			

In 3 of the 74 cases of carcinoma of the cervix which form the material for this study large mesenteric nodes were observed, and peritoneal seeding was found in 10 other cases. On this basis, one is justified in assuming that obstructive infarction might also be produced by a pure squamous-cell carcinoma.

Another type of obstruction is described by Lacassagne. The actual occurrence of the mechanism is not definitely established, however, since the cases which he reported were not controlled by autopsy. In 2 of 7 cases in which massive prevertebral lumbar nodes were observed after permanent healing of the pelvic lesions, the intestine was "compressed" and symptoms of obstruction were present. Retroperitoneal metastases were observed in 9 of the 74 cases which we studied, but either the nodes were not bulky enough to impinge on the bowel or their location was not such as to produce obstruction. These observations suggest that as control of the lesions in the pelvis by radiation becomes more general, this mechanism of intestinal obstruction is likely to become of more clinical importance.

A résumé of the clinical and pathologic characteristics exhibited in this series (Table II) shows that the cases fall into two groups. In 5 cases obstructive symptoms dominated the picture, the patients applying to obtain relief from the intestinal condition rather than for treatment of the neoplasm. The other 4 patients had been treated for carcinoma of the cervix and obstruction developed later, while they were being followed up. The 5 patients in the first group complained of intermittent colicky abdominal pain associated with nausea, vomiting, and abdominal distention. The disturbances had been present for one to three weeks in the patients with rectal lesions (Cases 1, 3, and 9), and at intervals for three months in the patients with obstruction of the ileum (Case 8) and of the sigmoid (Case 6). In these cases the symptoms had been mild and intermittent in the beginning but had become much worse just prior to the patients' admission to the hospital.

In all 5 cases the manifestations of intestinal obstruction were so typical that the diagnosis was made clinically. Sigmoid colostomy was performed in Cases 1 and 3, and resection of the ileum in Case 8. All 3 patients died shortly after operation. In Case 9 drainage of a pelvic abscess by colpotomy brought relief for ten months, and in Case 6 the patient survived seven months under conservative treatment.

In the other 4 cases the patients had been under observation for periods varying from six to sixteen months prior to the onset of obstruction. Rectal constriction was present in all the patients in this group, and Case 9 might also be included in it, since this patient had been under observation for ten months when her second constriction developed. In addition to the rectal involvement, ileal stenosis was also present in Cases 5 and 7. The symptoms complained of by all the patients in this group were milder and progressed more slowly than in the

first group. Distention, constipation, dyschesia, and abdominal pain were always present, but were so vague and inconstant and so obscured by other manifestations of the disease that the gravity of the obstruction was not recognized and no effective treatment was instituted.

In 2 instances (Cases 2 and 9) the cause of death was uremia. One patient died of sepsis (Case 4) and another of generalized carcinomatosis (Case 6). The remaining patients died of intestinal obstruction, which thus was the immediate cause of death in 6.7 per cent of the 74 patients who came to autopsy.

COMMENT

An extensive search of the British and American literature has revealed no titles directly concerned with the tendency of carcinoma of the cervix to cause intestinal obstruction. Ewing mentions infiltrative compression of the rectum and Healy states that colostomy is sometimes required to relieve obstruction. Brief reference to the subject is made by Cutler and Buschke, Cade, Warren, and Stout. Healy and Frazell, in 626 clinical cases of carcinoma of the cervix, found 9 rectal strictures, 3 of which required "operative interference." Maliphant, in a study of 500 cases, found 8 instances of intestinal obstruction due to carcinomatous stricture. Gal, in a clinical survey of 2,320 cases, found carcinomatous involvement of the rectal mucosa in 13 patients, but does not mention obstructive lesions.

Halter seems to be the only author who has attempted a comprehensive study of the subject. In an analysis of 453 inoperable cases of carcinoma of the cervix he found anatomic changes in the lower portion of the intestine in 87 cases (19.2 per cent). In our series of 74 cases, which can fairly be considered analogous, the incidence of rectal involvement was 21.6 per cent, a reasonably close agreement. In 11 of Halter's cases obstructive symptoms figured prominently in the clinical picture. He considers obstruction to be an important factor in the development of fistulas and stresses encirclement of the rectum opposite the level of the portio. We have already commented upon this type of involvement.

In an earlier study of 57 consecutive autopsied cases of carcinoma of the cervix one of us (B. P.) found 14 instances of rectal involvement, exclusive of fistulas. Stricture was present in 7 cases, in 3 of which colostomy was required, and death resulted from unrelieved intestinal obstruction in another case in this group.

The therapeutic measures ordinarily instituted for intestinal obstruction are applicable in the cases in which it develops from carcinoma of the cervix. Decompression of the colon by tidal irrigation, as advocated by Wangensteen, is useful, and Treves states that symptoms of low-grade obstruction in advanced cases of cervical carcinoma can be controlled by mild purgation and careful attention to diet. Colostomy,

however, seems to be an inescapable step in most cases, and can contribute greatly both to the patient's comfort and to prolongation of life if it is not delayed too long. It has been performed with increasing frequency and with gratifying results on our service in the New Orleans Charity Hospital during the past year, and a deliberate effort is now being made to discover incipient obstructive lesions. The value of the operation is well illustrated in the following cases, which are not included in this series because they did not come to autopsy:

Mrs. S. D. (HI-40892), a white female, 42 years of age, was treated with radium and x-ray in April, 1933, for squamous-cell carcinoma of the cervix. In October, 1933, she developed obstipation which lasted for nine days. Exploratory laparotomy showed the uterus to be adherent to the left pelvic wall, and annular constriction of the sigmoid caused by tumor extensions. Colostomy was performed. The patient remained symptom-free until May, 1935, when reactivation of the growth apparently occurred. She died in July, 1935, nineteen months after operation.

C. R. (HI-69541), a colored female, 48 years of age, had had a supravaginal hysterectomy for uterine leiomyoma in 1920. She entered the hospital in April, 1936, with transitional-cell carcinoma of the cervical stump, for which she was treated with x-ray (1,500 r. × 4 over the pelvis), followed by the interstitial application of radium (2,400 mg. hr.). In April, 1937, she developed an obstruction of the rectum due to carcinomatous stricture, for which colostomy was done. She remained well until July, 1938, when a vaginointestinal fistula appeared. Roentgenologic study of the gastrointestinal tract showed a communication between the ileum and the vagina. The lesion was thought to be a radiation injury and no surgery was attempted. Although the patient was alive in December, 1939, she was too ill to make the trip to the hospital and she died shortly afterward. The known period of survival after colostomy was thirty-two months.

It is worth pointing out that rectal involvement does not necessarily mean that the patient's condition is hopeless. Gal treated several of his patients with carcinoma of the cervix with extension to the rectum by the implantation of radium, and 2 were known to be alive and well ten years and thirteen years later.

SUMMARY AND CONCLUSIONS

In 74 squamous-cell carcinomas of the cervix which came to necropsy at Charity Hospital of Louisiana at New Orleans over an eleven-year period the incidence of carcinomatous obstruction of the bowel was 12.1 per cent. Intestinal obstruction was the immediate cause of death in 6.7 per cent of this series. The case records and the types of obstruction are discussed. In 5 cases the intestinal obstruction initiated the clinical picture. Obstruction also develops insidiously in treated cases, with symptoms so obscure that alertness is required for its recognition. Colostomy is an effective palliative measure and rectal involvement deserves vigorous treatment, for an occasional so-called cure may be obtained. A plea is made for early detection and prompt, adequate treatment of obstructive intestinal lesions arising from carcinoma of the cervix, to effect better palliation and secure longer survival.

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Recent Advances in Surgery

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RECENT ADVANCES IN THE SURGICAL TREATMENT OF CARCINOMA OF THE COLON AND RECTUM

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SINCE it is our purpose to discuss recent advances which have taken place in the surgical treatment of cancer of the large bowel, it seems fitting that attention should first be directed to information obtained from the fields of radiology and pathology to which surgery must remain indebted for a clearer definition of the problem involved.

RADIATION THERAPY

Radiation therapy for these lesions has had an extensive trial. With the accessibility of rectal cancer, interstitial radon application was a natural development. Likewise, radiation therapy alone or in conjunction with radium was extensively used. A sufficient amount of clinical data based on the use of modern equipment and methods is now available to justify several conclusions.

Foremost is the now well-established fact that in general these cancers are markedly radioresistant.[26] Unfortunately the surrounding tissues frequently display little, if any, greater resistance than do the neoplasms to which they give rise, with the result that dosages calculated to destroy the growth almost invariably produce extensive necrosis and at times sepsis. It seems reasonable to conclude further, by analogy with cancers of the breast, oral cavity, and so forth, that secondary deposits in the regional nodes are probably even less affected by this form of treatment than are the primary tumors themselves. Since it is not possible to determine by clinical means when and to what extent these metastases are present, the benefits to be derived from irradiation alone become still less certain.

Despite these unfavorable circumstances, as high as 50 per cent five-year survivals following these methods have been reported among a small selected group of rectal carcinomas.[3] As might be expected, however, even this figure does not compare well with the five-year results of radical surgery which in a favorable selected group exceed 90 per cent. Occasional apparent cures of patients said to have inoperable lesions when diagnosis was made are also reported, though the particular criteria establishing inoperability are usually not cited.[23]

Finally, there is general agreement that a certain amount of palliation may frequently, though not invariably, be obtained as evidenced by diminution of symptoms and prolongation of life,[2, 24] It therefore seems reasonable to state that irradiation should be strictly reserved as a primary form of treatment for cases that prove technically inoperable, which in our experience represents but 15 per cent of our cases.

PATHOLOGY

Further definition of the problem has been presented by the painstaking work of Westhues,[30] Gabriel, Dukes, and Bussey,[9] and by Gilchrist and David.[10] Careful examination by them of accumulating surgical material has shown the incidence of node metastasis in rectal carcinomas to be in the neighborhood of 60 to 70 per cent. This is about twice as high as had previously been realized. It is probable that similar care in the examination of colon specimens would be equally surprising.

A consideration of these facts clearly delineates the problem and indicates both the type and extent of treatment necessary to meet it. By present day methods a reasonable chance of cure may obviously be obtained only by wide resection of the primary tumor accompanied by as complete a regional node removal as is anatomically possible. To accomplish this, adjacent invaded organs, such as a segment of small intestine or ureter, a portion of the urinary bladder, the uterus and its adnexa, or portions of the vaginal wall or prostate must frequently be removed en bloc with the tumor. When in rectal tumors there is extensive involvement of the inferior mesenteric node chain, the inferior mesenteric artery may be ligated at the point where it leaves the aorta in the expectation of remaining above the diseased nodes.

OPERATIVE MANAGEMENT

Such increasing radicalness of thought is reflected in a steadily rising operability rate which began at the Lahey Clinic at 58.3 per cent in 1929 and has risen to 84 per cent during the past two years. The figures of others have indicated a similar trend.[6, 13, 14, 22] In addition, the incidence of abdominoperineal rectal resections performed has risen to 85 per cent, the less radical posterior resection and the anterior resection being employed in a diminishing number of instances.

One of the chief factors making this possible has been the two-stage rectal resection first described by Lahey[16] in 1930, and since somewhat modified.[18] This plan of procedure has permitted the acceptance for resection of many aged patients with degenerative circulatory changes which leave them on the verge of cerebral accidents, cardiac failure, and uremia. Actually, 9 per cent of patients on whom resection is performed at the clinic are between seventy and eighty years of age. When perforation of the tumor with abscess formation has occurred, drainage may be instituted at the first stage, thereby permitting a

much easier subsequent removal of the tumor without the risk of spreading infection. Many patients in whom extension of the growth to contiguous organs or structures has taken place, and who for other reasons are poor risks, have proved safely resectable by this means whereas the hazards of a Miles operation would almost certainly have been too great. In 16 per cent of instances it has been necessary to remove either partially or entirely some adjacent organ or other structures.

In general, then, the two-stage operation has permitted more of the usual radical resections in poor risk patients and a greater number of the more extensive procedures in the good and average risk groups. This is true because rectal resection done as a second stage procedure is physiologically less disturbing than when carried out in one stage. There are several good reasons for this: (1) A well-functioning colostomy is already present; (2) careful exploration of the abdomen and division of the bowel have already been done at the first stage, thereby confining the second stage entirely to the pelvis; (3) coincident infection can be more adequately cared for either by actual drainage at the first stage (if perforation has occurred) or by irrigation of the tumor segment between stages; and (4) the resection may be done in less time for not only has the colostomy been already prepared but the surgeon now knows exactly what must be done even before the abdomen is opened. In recognition of these advantages the two-stage operation is now carried out in about one-half of all resected cases.

From time to time various objections to this procedure have been raised: (1) The opportunities for the development of those complications which may follow any operation are doubled, (2) the abdomen is entered the second time through a potentially infected field, (3) adhesions resulting from the first stage may make the second stage more difficult than a Miles resection, and (4) the lapse of two weeks provides additional time for metastases to occur. The first of these objections is a valid one but is more than compensated for by the increased operability permitted and by the proportionately better individual chances for cure offered because more patients are treated by the abdominoperineal method and fewer by the less radical posterior resection. The second objection is sound in theory only. In actual practice, wound infections are rarely seen after the second stage operation and peritonitis has been largely eliminated as a cause of postoperative death. In answer to the third argument, it may be stated that if the first stage has been properly done troublesome adhesions rarely will be found at the second stage. Regarding the possibility of metastases occurring during the fourteen-day interval between stages, it may be said that this factor must be small indeed when one considers that the average duration of symptoms from onset to application for treatment is from nine to twelve months. It is of little value to mention operability figures without discussing at the same time operative mortality and end results.

When approximately nine of every ten patients seen are being operated on, it becomes obvious that the hazards in some are unavoidably high. During the same period (1929-1939) previously mentioned, during which the operability steadily rose, the operative mortality dropped from 36 per cent to 12.4 per cent. There is little doubt that if all patients could be operated upon during the time when their lesion is still confined to the bowel wall—and this is unfortunately true of less than one-third of the total number—the immediate mortality could probably be kept in the neighborhood of 5 per cent.

If a reasonable operative mortality in surgery of the large bowel is to be maintained, strict attention to three important factors is essential:

1. Adequate preoperative preparation.

2. A carefully planned system of operative procedure in which untoward eventualities are anticipated.

3. Institution of certain measures designed to reduce or eliminate postoperative complications.

It is not possible to lay down any rule as to how long a preoperative period of preparation is necessary. There are a few very good-risk patients with small lesions for whom three days would suffice. At the other extremity are those dangerous-risk patients who present, in addition, advanced lesions which forecast difficult surgery. Preparing such patients will require more time and much thought. A safe formula would be to allow as long as is necessary for an optimal re-establishment of function both local and systemic. When a two-stage operation is decided upon preoperatively, a short period should suffice.

The necessity for thorough decompression of the gastrointestinal tract, especially when some degree of obstruction is present, is now generally appreciated. Measures undertaken to fortify lowered cardiorenal reserve, and to replace deficient fluid, salts, and blood, it must be remembered, are no less important. It is doubtful if there is anything to be gained by the preoperative administration of vitamin concentrates unless there is good reason to believe that previous intake has been inadequate.

There are probably no two surgeons whose operative management of these cases is identical and it is in many respects true that for each his way is best. However, because of the frequently unsuspected situations which can arise during large bowel surgery, certain measures are routinely incorporated in all of these procedures because of the added safety which they contribute.

Most important among these is spinal anesthesia. The complete muscular relaxation which it affords permits easy exposure of the operative site, makes the frequent rehandling of the small intestine unnecessary, and allows unhampered wound closure. These advantages can only be fully appreciated when such unforeseen misfortunes as the inadvertent entering of an abscess cavity, or troublesome bleeding deep in the pelvis,

are superimposed on an already difficult problem. Either pontocaine-glucose[20] or nupercaine[12] is used.

It has also become a routine policy to have an intravenous infusion of normal saline solution running before operation is begun. Its purpose is to provide the anesthetist with a quick and easy means of responding to variations in the patient's general condition by the prompt administration of appropriate intravenous medications or blood. Prolonged drops in blood pressure as well as other less serious incidents are thereby prevented. Usually an ankle vein is selected because the necessary manipulation can be carried out here without interfering with the progress of the operating team.

Since it is rarely possible to predetermine exactly what type of procedure shall be suited to the peculiar exigencies of each case, the type of incision employed is important. This is particularly true for lesions distal to the midpoint of the transverse colon. The ideal incision should permit easy exposure for the carrying out of whatever type of operation seems necessary and should also, in healing, leave a solid abdominal wall. We believe that an incision through the outer third of the left rectus muscle fulfills both of these qualifications. It allows easy exploration of all of the abdominal viscera and may easily be extended either upward or downward for sigmoid or transverse colostomy (either of the loop or Mikulicz types) or for one- or two-stage abdominoperineal resection of the rectum. When freeing of the splenic flexure is necessary, this may be somewhat more easily accomplished here than through a midline incision. It is possible that this incision results in a somewhat higher incidence of weakness of the abdominal wall or even hernia, but in our opinion, the ease of carrying out the difficult operative procedure more than compensates for this possible disadvantage.

Among the postoperative complications of large bowel surgery, shock and peritonitis have in the past occupied the positions of primary importance. Serious grades of the former have now been satisfactorily disposed of by routinely transfusing either during or immediately following operation. Peritonitis has been largely eliminated by the employment of the exteriorization resection (modified Mikulicz) type of procedure for all colon lesions except those low in the sigmoid. In tumors of the right colon such an operation has its greatest usefulness, for the relative thinness of this side of the bowel as compared to the more distal portions, as well as the higher degree of infectiveness of its contents makes anastomosis in this region especially hazardous. The technique followed in Mikulicz resections of the right colon is that described by Dr. Lahey[17] in 1931. In view of the recent trend in the treatment of carcinoma of the right colon away from one-stage resection toward anastomosis followed by resection at a second stage,[1, 21] the Mikulicz operation may be said to have still another recommendation, namely that it involves but a single entering of the peritoneal cavity, the subsequent colostomy closure being accomplished entirely outside the peritoneal cavity.

Postoperative urinary complications are seen primarily following removal of the rectum and occur in about 75 per cent of these cases. Ewert[7] has recently reported the experience at this clinic in the management of these complications. They are rarely fatal but may be extremely troublesome and usually result from injury to the pelvic parasympathetic nerves (nervi erigentes) arising from sacral segments two, three and four. Stretching or severing of these fibers produces diminution in bladder tone, the degree and duration of which is proportionate to the extent of injury. Resection of large infiltrating tumors of the upper rectum and rectosigmoid is most apt to cause bladder atony.[25] To prevent urinary stasis, further loss in muscle tone, and ensuing infection, it is useful to employ constant closed bladder drainage by means of an indwelling catheter for seven to ten days postoperatively. Occasionally slightly longer periods are necessary. In males moderate degrees of prostatic obstruction previously unnoticed may become evident because of weakened detrusor action, and are relieved by transurethral resection.[7]

END RESULTS

To quote end results it is necessary to present cases of patients operated upon five years or more ago.[4] Of all patients seen between 1931 and 1934 inclusive, 57 per cent of those having carcinoma of the rectum and 55 per cent of those having carcinoma of the colon were subjected to resection. The combined operative mortality was 14.5 per cent. The five-year survival rate among resected cases was 44 per cent for the rectal group and 54 per cent for the colon group. Of all cases, both resectable and nonresectable, the total salvage was 25 per cent in carcinoma of the rectum and 29.4 per cent in carcinoma of the colon. It is anticipated that, with the present operability figure now ranging around 85 per cent and with a somewhat smaller operative mortality, about one-third of all these patients may be expected to survive the five-year period. The five-year survival rate will not, however, increase proportionately with the rise in operability for not only does this latter reflect attempts at curing the more advanced and poorer risk patients whose prognosis is known to be bad, but it also indicates an attempt at palliation for some patients who are beyond hope of cure. Actually, 10 per cent of all resections are now done in the presence of liver metastases. It therefore seems unlikely at the present time that anything additional will be accomplished by this means.

FUTURE ADVANCES

Further advances can only result from more widespread attempts at earlier diagnosis. Swinton and Higginbotham[29] recently demonstrated in 300 patients with cancer of the rectum or colon that 97.5 per cent complained of some form of bowel dysfunction. Yet the average time elapsing before a correct diagnosis was made averaged nine to twelve months in the rectal and colon cases respectively. Comparison with a

similar study done five years earlier indicated that the diagnoses at present are being made no earlier than they were at that time. About 30 per cent of the patients with rectal disease seen at the clinic had been given treatment for hemorrhoids within six months prior to the establishment of the diagnosis of carcinoma. About 15 per cent of patients with right colon tumors are operated upon for appendicitis before a correct diagnosis is made. The truth of such figures is attested by the fact that only 15 to 30 per cent of the growths still remain limited to the bowel wall at the time of operation and may, therefore, still be considered early.

Nevertheless, the diagnosis of cancer of the large bowel is not difficult and can almost invariably be made by one of three simple procedures, which in relative order of importance are:

1. Digital examination.
2. Sigmoidoscopic examination.
3. Barium and contrast enema.

Since carcinoma of the rectum makes up a little more than 50 per cent of all malignant large bowel growths, digital examination alone will account for approximately that number. An additional 25 per cent may be diagnosed on sigmoidoscopy and the remainder by barium enema. Very occasionally suspicious but inconclusive roentgenologic findings will require exploratory laparotomy for verification.

The practice of ordering a barium enema without having done at least a digital examination has resulted in many a missed diagnosis because the negative x-ray report usually obtained induces a false sense of security. The late Dr. D. F. Jones frequently emphasized this.

What can be accomplished by early diagnosis has been clearly demonstrated in many recent reports dealing mainly with cancer of the rectum. As long as the growth remains confined to the rectal wall the chance of cure is better than 90 per cent. When the perirectal tissues become invaded and the nodes still remain free of disease, from 60 to 70 per cent probability of five-year survival still remains. After regional node involvement has taken place, however, the opportunity for cure falls to between 15 and 20 per cent.[11]

There is little doubt that many if not all cancers of the large bowel originate as benign polyps. Junghanns[15] found evidence to support this relationship in 70 per cent of cases of carcinoma of the colon studied. On the other hand, all benign polyps do not become malignant, though none may be relied upon to remain benign. Opinions vary as to what percentage eventually undergoes malignant change. Among those that do, however, there must exist a variable time period of transition which provides a precious margin of safety from the standpoint of diagnosis. Obviously then, a large measure of future success must depend on the more general search for, and recognition of, these precancerous lesions. Their high incidence should accordingly be mentioned. It probably ranges around 5 per cent (Susman,[28] 6 per cent; Stewart,[27] 4.19 per

cent). Lawrence[19] has reported the low figure of 2.37 per cent, but one-quarter of his cases were children. Feyrter[8] has reported an incidence of 21.5 per cent (probably too high) and has pointed out, as have others, the rising frequency of occurrence with advancing age. Such studies are based on large series of consecutive autopsies and may properly be considered to represent cross sections of the population.

The diagnosis of polyps depends largely on proctoscopy and the contrast enema. Even large rectal polyps may frequently be missed on digital examination because of their soft consistency. The discovery of polyps on digital or proctoscopic examination always calls for complete large bowel study by barium and contrast enemas, not only in the search for other polyps but to rule out carcinoma. Such enemas should be repeated at appropriate intervals probably not greater than six months in order to detect the development of carcinoma in its incipiency. Accessible polyps should be dealt with locally and here fulguration alone or, sometimes better, combined with low penetration irradiation of their base is indicated. Bulky polyps of the colon may be treated by colotomy and local removal.[5] It should be mentioned here that in any exteriorization resection procedure done on the colon, closure of the resultant colostomy should not be accomplished until both loops have been colonoscoped as far as is possible and all polyps destroyed.

SUMMARY

1. The discouraging results of irradiation therapy and the high incidence of regional node metastases have greatly clarified the surgical problem involved in the treatment of carcinomas of the colon and rectum.

2. Increasing radicalness in the removal of the primary tumor as well as of the lymphatics draining it has been the result as indicated by a steadily rising operability rate.

3. Much credit for making this possible is due to the advantages of the two-stage rectal resection.

4. The accompanying decrease in postoperative mortality is largely attributed to more careful preoperative preparation, increasing operative experience, and the employment of certain measures aimed at preventing the more serious postoperative complications.

5. The end results in patients treated during the years 1931 to 1934 inclusive have been cited and the hope expressed that with the more recently increased operability even a greater number will be permanently benefited.

6. Any appreciable future advances, it is believed, can be made only through more widespread attempts at earlier diagnosis.

7. The role of intestinal polyps in the development of carcinoma is discussed.

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Review of Recent Meetings

REVIEW OF THE SOUTHERN SURGICAL ASSOCIATION MEETING, DECEMBER 9-11, 1941, PINEHURST, N. C.

D. HENRY POER, M.D., ATLANTA, GA., AND GUY W. HORSLEY, M.D., RICHMOND, VA.

(From the Departments of Surgery, Emory University, and Medical College of Virginia)

THE FIFTY-FOURTH Annual Session of the Southern Surgical Association was held December 9, 10, and 11, 1941, at the Carolina Hotel, Pinehurst, N. C. Attendance was the largest in the Association's history with 154 members and 170 visitors and guests registered. Thirty-seven of the forty listed papers were read.

H. H. Kerr, Washington, D. C., gave the **Presidential Address** during the annual banquet of the Association and discussed the **Importance of Proper Selection of Men for Our Armed Forces** during the present conflict. He stressed the need for more complete psychiatric examinations to weed out the mentally unfit since this group has become such an economic liability since World War I. He also discussed the surgical program for the present mobilization and improved treatment methods that have done much to lower mortality and restore injured soldiers to front-line service in a minimum time.

1. **J. D. Rives,** New Orleans, La.: **Anatomy of the Attachments of the Diaphragm and the Relation of these Attachments to the Problems of the Surgery of Diaphragmatic Hernia.**—Causes of diaphragmatic hernia were found to be (1) defects in the development of the diaphragm, (2) trauma, and (3) infection. The author noted that the weak gap in the development of the diaphragm was found more frequently in the left side. He described methods for operative relief of anterior defects which was accomplished by dissection of the transversus muscle allowing the diaphragm to be pulled over the defect. Thus the muscle becomes part of the diaphragm. Omentum was used to cover raw area. For closure of posterior defects he suggested resection of the tenth rib, sliding a flap of the latissimus dorsi muscle over the defect and suturing it to the margin of the diaphragm. Results were satisfactory after a 2-year period.

2. **S. W. Harrington,** Rochester, Minn.: **Diaphragmatic Hernia.**—The results of a study of diaphragmatic hernia in children was presented and compared with the same condition in adults. He noted that from 1908 to 1923 there were only 34 cases at the Mayo Clinic, two being in children, but from 1926 to 1941 there were 700 cases, 304 of which came to operation. Of these 283 were in adults, with eleven deaths and 24 in children, with four deaths. The majority of all deaths were caused by cardiorespiratory disease often associated with pneumonia or pulmonary collapse. He noted an increasing hazard of the operation as the child grew older and advocated surgery as soon as the diagnosis was made. Management of diaphragmatic hernia in children was different because most were due to congenital developmental defects, while the hiatus hernia was frequently seen in adults. The short esophagus and pleuroperitonealis types were observed in children.

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Discussion: **A. O. Singleton,** Galveston, Texas, pointed out the need for the roentgenologist becoming more "conscious" of diaphragmatic hernia. He questioned the point of approach and preferred the transthoracic without removal of the ribs, to the abdominal. He found the cases with congenital absence of a portion of the diaphragm most difficult to repair and mentioned the use of large pieces of autogenous graft. In closing, Rives stated that he approached this type through the abdomen using transplants of the transversalis abdominis muscles attached to the dome of the diaphragm. Harrington also approached this type through the abdomen. He stated that the phrenic nerve should be interrupted in most cases.

3. **A. W. Allen,** Boston, Mass.: **Gastric Resection for Duodenal Ulcer: Follow-Up Studies.**—Of 2726 cases of duodenal ulcer treated at the Massachusetts General Hospital, 588 or 21 per cent had surgical methods used. Operation was performed for perforation in 24.3 per cent, for obstruction in 32.8 per cent, and for pain or hemorrhage in 31.9 per cent. Posterior gastroenterostomy and resections were done in the same number of cases with identical mortality (9.3 per cent). The popularity of resections has increased during the past 4 years with a corresponding decrease in the number of posterior gastroenterostomies. Sixty-seven marginal ulcers were observed following posterior gastroenterostomy, two as late as 18 years although two-thirds of the whole occurred within 2 years of operation. The results following the Finsterer exclusion operation were poor, and only fair following pylorectomy, but were noted to be good following subtotal resection.

Twenty-six resections were performed since 1938 with five deaths, and one poor result. Other cases are apparently cured. Peritonitis, pneumonia, hemorrhage, fistula, and stricture of the common duct caused the complications observed in this series. Allen concluded that the results were better and the mortality lower following subtotal resection, provided at least one-half of the stomach and the pylorus including the pyloric sphincter are removed.

4. **Waltman Walters,** Rochester, Minn.: **Gastric Ulcer or Ulcerating Carcinoma** (abstract).—It was noted that some gastric ulcers heal satisfactorily but that many recur at a later date. No conclusive evidence concerning the healing of chronic ulcers under medical treatment could be found. Roentgenography and gastroscopy could not be relied upon entirely to exclude malignancy and the author cited illustrative cases. Since gastric acidity and tissue susceptibility cannot be continuously controlled under a medical regime, he considered recurrences understandable. In proved cases of gastric carcinoma, the first symptom was that of ulcer in 33 per cent and an "effective" response to medical treatment was obtained in 80 per cent of cases of cancer with ulcer symptoms. The diagnostic value of gastric acidity was lessened when he found that only 50 per cent of patients who had carcinoma had gastric anacidity and that in 20 per cent of the cases the value for the gastric acidity was as much as 30 according to the method of Töpfer. Walters preferred gastric resection for treatment of large chronic ulcers that do not respond to medical treatment. He called attention to the fact that a roentgenographic report of gastric ulcer had been made concerning 10 per cent of a large group of patients operated on for cancer of the stomach.

Discussion: **F. W. Bancroft,** New York, N. Y., described an interesting case of ulcer on the lesser curvature in which one-half of the ulcer was found to be malignant at operation in 1930. A second operation recently performed revealed a marginal ulcer with hemorrhage. He advocated coring out of the mucous membrane of the pylorus when its removal is impractical, and also included a part of the normal stomach. **R. L. Sanders,** Memphis, Tenn., also had observed the increasing popularity of gastric resection for chronic ulcer in comparison to

posterior gastroenterostomy and stated that his results justified the change. He stressed the importance of removal of the pylorus to insure good results. **R. L. Payne,** Norfolk, Va., discussed the problem of closure of the duodenal stump and requested information in regard to preventing a duodenal fistula. In closing, Allen emphasized the necessity of performing a complete operation including removal of the pylorus. To prevent duodenal fistula, he stated that enough cuff of bowel was needed for two rows of sutures for infolding and advocated a two-stage procedure if necessary. Walters stated that the results of gastric resection for chronic gastric ulcer were almost perfect, but, when partial gastrectomy was performed for duodenal ulcer, in his experience, recurrence took place in 2 per cent of the cases.

5. **Mims Gage,** New Orleans, La.: **Aneurysm of the Abdominal Aorta: Failure of Obliteration by Ligation** (abstract).—A review of the literature on ligation of the abdominal aorta for aneurysm was outlined. The author reported a case of aneurysm of abdominal aorta in which he ligated the abdominal aorta above the bifurcation with cotton tape. The pulsations returned in the aneurysm sac. Three months after ligating the aorta, he ligated the right common iliac with three ligatures. It was then discovered, due to shrinkage of the sac, that the aneurysm was one occurring at the bifurcation of the common iliac which had ruptured. Both procedures failed to cure the aneurysm. Gage reviewed 35 cases and found that syphilis and arteriosclerosis were the chief causes of weakness of the aortic wall that resulted in aneurysm formation. Signs and symptoms included pain, the presence of tumor (expansile pulsation 50 per cent), pulsation of the tumor, and a bruit. Experimentally, the dog's aorta (which cannot be compared to the human aorta) had been occluded with: (1) round ligatures, (2) flat cotton tape, (3) metal bands, clamp and compressors, wire, tin, and aluminum, (4) rubber bands, spring devices, fascia plugs, cellophane, and sclerosing solutions. In the human being, ligatures have consisted of cotton tape, braided silk, fascia lata and aluminum bands, intra-aortic plugs of fascia, and steel springs. Complications usually result from rupture of aorta at the site of the ligature (especially round ligatures and metal bands) or the aneurysm sac itself. Paralysis of the legs and urinary bladder does not infrequently occur but fortunately is a temporary affair. Gangrene also occurs following ligation and is due to inefficient collateral circulation. This is a very serious complication. Sudden elevation of the blood pressure occurs, with acute dilation of the heart. Decreased cardiac output and embolism also may result. Treatment requires adequate development of collateral circulation plus obliteration of the aorta and aneurysm sac. In aneurysms of the bifurcation, lumbar sympathectomy of the thoracic aorta (Smithwick's thoraco-abdominal procedure) is advocated.

6. **James C. Owings,** Baltimore, Md.: **Successful Experimental Ligation and Division of the Thoracic Aorta.**—The successful ligation and division of the thoracic aorta in four experimental animals (dogs) was described. The author reviewed Halsted's experimental work and considered his failure to be due to the fact that (1) the change in the caliber of the vessel was produced too abruptly and (2) a nonyielding material was used. He used wide rubber bands which yielded sufficiently to prevent cutting through of the vessel wall and yet produced gradual compression of the vessel. The bands were applied in three stages and the vessel divided after about three or four months when collateral circulation was sufficiently developed.

Discussion: **Harvey B. Stone,** Baltimore Md., emphasized the importance of this work citing the new conceptions of vascular surgery that had resulted from it. **Barney Brooks,** Nashville, Tenn., likewise mentioned the value of these experiments and stated that possibly the hypertension produced may be due to the same causes as that produced by the Goldblatt clamp in cutting of the

blood supply to the kidney. In closing, Owings stated that study of the kidneys showed normal function and section and the hypertension therefore was not the same as that produced by the Goldblatt clamp. He stated that the rubber bands stay when they are placed and maintain their elasticity, but occasionally a band had cut through the vessel.

7. **George G. Finney** (and **John K. Owen,** by invitation), Baltimore, Md.: **The Surgical Aspect of Congenital Absence of the Gall Bladder with Report of Two Cases** (abstract).—Reports of forty-six instances of congenital absence of the gall bladder without any congenital anomaly were found in the literature by the authors and 2 cases were added. Stones were found in the ducts in the 11 cases where full data was given. The common duct was usually dilated with obstruction of the ducts, pain, and jaundice. The first patient, a 68-year-old male, entered the hospital complaining of acute abdominal pain thought to be produced by biliary colic. He had an old ulcer history dating back some 10 or 12 years. At operation, exploration revealed the scar of an old ulcer, but no gall bladder could be located. The common bile duct was dilated only slightly, but when opened, two imbedded stones were removed. The second patient, a female 69 years of age, also had abdominal pain indicative of biliary colic and evidence of cardiac decompensation. No gall bladder was found at operation and the common bile duct was dilated and contained two stones. The first patient recovered but the second one died 24 hours after operation due to cardiac failure. Autopsy revealed no evidence of gall bladder either extra- or intrahepatic. **Hugh H. Trout,** Roanoke, Va., told of a case in which gall bladder visualization showed evidence of a double gall bladder, only one of which contained stones.

8. **Harold L. Foss,** Danville, Pa.: **Intestinal Obstruction Due to Gall Stones.**—The high mortality resulting from intestinal obstruction caused by gall stones was pointed out by the author and the frequency of such obstructions among all obstructions was found to be 4 per cent in his clinic. The stone usually passes by cholecystenteric fistula. Symptoms were those of ileus and may be absent or intermittent. Stones usually lodge in the lower ileum (78 per cent), but also have been found in other portions of the intestine or colon. The duration of the obstruction before hospital admission of the author's 10 cases was 5.2 days and the mortality 50 per cent. Delay was mentioned as the chief cause of the high mortality.

Discussion: **Edward V. Mastin,** St. Louis, Mo., presented 5 cases in which gall stones caused intestinal obstruction and advocated loop ileostomy as a method of lowering the high mortality. This was successful in the 3 of his cases in which it was used. **George G. Finney,** Baltimore, Md., added 3 cases with one death. One of these had two operations.

9. **Edwin P. Lehman,** Charlottesville, Va.: **Annular Pancreas as a Clinical Problem** (abstract).—A case of annular pancreas, one of 48 in the literature, was reported. A discussion of the clinical aspects of the 9 previous cases that had come to operation was given and a case presented which was the first in which the diagnosis was made before operation. The anomaly is the result of incomplete migration of the ventral anlage and apparently creates symptoms only when pancreatitis occurs. The symptoms are those of chronic duodenal obstruction. Although posterior gastroenterostomy has been the more popular operation, direct division of the ring with or without resection is advised.

10. **A. O. Singleton,** Galveston, Texas: **Splenectomy.**—The indications for splenectomy are given and also a technical presentation which is calculated to lessen the operative mortality in splenectomy. A lateral transverse incision is given which is anatomic in most details and gives excellent exposure of the operative field. This incision not only gives good exposure of the operative field but preserves the integrity of the abdominal wall.

Preliminary ligation of the splenic artery and a systematic control of the circulation of the spleen before it is delivered out of the abdomen assures an almost bloodless operation. The splenic bed is readily approached for the control of the oozing vessels before closure of the abdomen is done. Illustrations and motion pictures were given to clarify these statements.

11. **Joseph E. J. King,** New York, N. Y.: **Oxycephaly** (abstract).—A description of the operation first proposed and carried out by the author in 1936 was given and the details of 4 cases presented. Two of these were operated upon by Barnes Woodhall of Duke University Hospital by the same method. The condition of oxycephaly is due to premature closure of the suture lines, and unless the process is arrested these patients never reach adulthood. The symptoms and signs are headaches, irritability, marked exophthalmos, failing vision, convulsions, and finally loss of eyeballs and life. Roentgenograms show marked similarity in all cases, i.e., generalized convolutional markings, depression of the fossae of skull, narrowing and deepening of the sella turcica, shallowness of orbits, absence of suture lines, and protrusion of lower jaw. The author described the method of surgical procedure used in his cases, which consisted of morcellation of the calvarium produced by making many burr hole openings, and cutting between them with a DeVilbiss rongeur to create numerous skull segments which readily adapted themselves in conformation position. This resulted in correction of the deformity and relief of the symptoms. The results were satisfactory.

Discussion: **M. B. Woodhall,** Durham, N. C., mentioned the 2 types of this condition, viz., (1) craniofacial with hyperplasia of the maxilla, and (2) skull deformity. He had operated upon three patients with restoration of cranial symmetry. He included subtemporal decompression in his operative procedure.

12. **Claude C. Coleman,** Richmond, Va.: **Treatment of Compound Fracture of the Skull** (abstract).—The main emphasis was placed on the importance of early complete operation on all open wounds of the head. The principles of treatment for contused laceration of the scalp were the same as those employed for more severe injuries such as compound fractures with laceration of the dura and damage to the brain. Coleman has found from analyses of several large series of acute head injuries that shock, as determined by clinical examination and blood pressure estimation, develops in less than 10 per cent of the total number of cases admitted to his clinic. Early operation, that is within 6 to 8 hours, can be done in a large majority of cases of compound fracture of the skull. If shock is present, treatment should be directed to this condition and everything avoided that would tend to increase shock. If complete operation is delayed because of shock, he advocated shaving the scalp around the wound, controlling external hemorrhage, dusting the wound with sulfanilamide crystals, and applying a sterile bandage. He further emphasized the thorough disinfection of the wound by large quantities of sterile solutions and the avoidance of chemicals. Macerated brain tissue, blood clot and other debris should be removed by the suction apparatus and hemorrhage carefully controlled. Another point stressed in the paper was the importance of closing the dura in all cases in which it has been torn by the fracture. Closure of the dura, he said, was especially important in fracture involving the frontal and ethmoid sinuses. Drainage has not been used by the writer in such cases. Chemotherapy is advocated in the treatment of all cases with dural penetration and in fractures of the base when it is believed that the dura has been lacerated. In a series of 224 compound fractures the total mortality was 16.5 per cent with operative mortality of 12 per cent.

Discussion: **Chalmers H. Moore,** Birmingham, Ala., stated that he used opposite methods of treatment. Shock was present in most of the patients seen by him and operation was delayed. At the end of 24 hours operation was carried out in the manner described by the author.

13. **Walter E. Dandy,** Baltimore, Md.: **The Diagnosis and Treatment of Ruptured Intervertebral Disc.**—Pertinent facts regarding the diagnosis of ruptured intervertebral discs based on careful study of signs and symptoms were presented. Dandy considered lipiodol and air injections unnecessary and frequently harmful because they could not disclose the lesion. He reviewed the history of the development of the operation for the relief of this condition, pointing out the fact that it has now been simplified and is performed without harm or risk. The question of "concealed discs" was discussed since 25 per cent of his series were of this type. He states that relief following operation was immediate or slow but permanent in his cases. Sixty-three cases had been operated upon in the past 8 months, a ruptured disc being found in each instance.

Discussion: **Chalmers H. Moore,** Birmingham, Ala., brought out the "compensation factor" in a series of 200 cases. The results of operation were good in 90 per cent without compensation, and bad in 85 per cent with compensation. He had similar experiences in 26 personal cases. **George E. Bennett,** Baltimore, Md., discussed the causes of low back pain and sciatica and outlined the many procedures carried out for their relief including manipulation, arthrodesis of sacroiliac joint, lumbosacral fusion, fasciotomy tenotomy of piriformis muscle, and the removal of ruptured intervertebral discs. **J. E. J. King,** New York, N. Y., requested information concerning hypertrophy of ligamentum flavum and also stated that if lipiodol is injected it should be removed on the same day. Dandy, in closing, stated that he was not convinced of the occurrence of hypertrophy of the ligamentum flavum. He also made the point that the backache due to rupture of intervertebral disc is recurrent and not constant.

14. **L. Wallace Frank,** Louisville, Ky.: **Sarcoma of the Small Intestine.**—A review of the recent literature on sarcoma of the small bowel showed the average age to be between 40 and 42. The symptoms are those of gradual obstruction associated with severe nausea and vomiting depending on the location of the lesion. Reports of 4 cases were given: (1) a spindle cell sarcoma in the terminal ileum, (2) a reticulum cell sarcoma in the jejunum—this case had symptoms of a duodenal ulcer and also bleeding from the bowel, (3) a lymphosarcoma in the jejunum 14 inches below the ligament of Treitz—this patient was a boy, aged 18 years who was thought at first to have an appendical abscess, and (4) a neurofibrosarcoma of the jejunum of an annular constriction type. All cases reported since 1932 were reviewed with the addition of these 4 new cases.

15. **Vernon C. David,** Chicago, Ill.: **Extension of the Indications for Radical Operation in Cancer of the Rectum** (abstract).—One of the chief problems in the radical operation for cancer of the rectum is to increase the limits of resectability. In those cases not operated upon the mortality is 100 per cent. David reported a series of 277 cases of which 179 had the tumor removed with a mortality rate of 7.2 per cent. One-hundred twenty-nine had a one-stage combined perineal resection, and there were 22 other cases which had obstruction resections or local removal of the tumor. The chief cause for inoperability is definite metastasis to the liver, fixation of the growth to the base of the bladder, or infiltration of the soft parts, particularly the prostate, rectovaginal septum and sacrum. In many cases the fixation of the tumor mass to the bladder, prostate or rectovaginal septum has not advanced to the point where resection of these various organs and tissues cannot be done at the same time radical resection of the rectum is carried out. There was only one patient who was refused operation on account of age. This patient was 81 years old and also had bronchitis. In this instance a colostomy alone was done. David's report shows that 38 patients over 65 years of age had removal of the tumor, with four deaths. There were: 18 between the ages of 65 to 70; 12 between the ages of 70 to 75; 4 between the ages of 75 to 80; and 4 between the ages of 80 to 85.

From his experience he stated while age is a hazard it should not be considered a contraindication to operation. Occasionally he thinks it is advisable to operate on patients where there are one or two doubtful nodules in the liver which may be metastases but also could be benign tumors of the liver such as adenomas or angiomas. The life expectancy of patients with definite liver involvment is about 10 months. Even though marked obesity makes the case more difficult, it is certainly not a contraindication. Sixty-five per cent of the patients with cancer of the rectum will show lymph gland involvement. The one-stage combined abdominal perineal resection is the operation of choice and in the last five years there have been only four two-stage operations as against 112 one-stage operation.

Discussion: **F. W. Rankin,** Lexington, Ky., agreed that everything should be done to extend the operability in these cases. He considered the one-stage modified Miles operation to give the best results, with an operation mortality of 5 per cent to 10 per cent. **Harvey B. Stone,** Baltimore, Md., stressed the value of the one-stage operation but when attempting to extend the indications for operability he varied the procedure. **W. B. Marbury,** Washington, D. C., discussed the use of a tube through a cecostomy in order to clean out the bowel if obstruction had taken place. He noted a lower infection percentage following this procedure. In closing, David pleaded for giving all doubtful cases a chance, since the nonoperative treatment is hopeless.

16. **John E. Cannaday,** Charleston, W. Va.: **The use of the Cutis Graft in the Repair of Certain Types of Incisional Herniae** (abstract).—Cutis takes on the function of either fascia or tendon if grafted between or in place of these structures. In obtaining the graft either Thiersch or split skin grafts are first taken from the donor site after which a graft of suitable size and shape is taken from the underlying derma including a layer of fatty tissue underneath about one centimeter in thickness. This constitutes the cutis graft. After the graft has been sutured into its new location and the repair operation has been completed, the area from which the graft has been taken is repaired either by closure with interrupted tension sutures or, in case a split skin graft has been removed, the latter is secured in place so as to cover the raw surface. If the cutis graft is to be used for repair of hernia or for replacement of tendon the thick graft from which the epidermis only has been removed is more satisfactory. In Cannaday's opinion, cutis has longer life than fascia, takes more readily, is not more liable to infection, and is more readily available. He particularly prefers it to fascia in the repair of large incisional hernias, especially in cases in which it is impossible to overlap the edges of the hernial opening. Cutis makes an excellent suture or ligature material and can be used satisfactorily in varied types of general surgery, also in bone and joint surgery for the replacement of ligaments, and in the reconstruction of joints of the long bones. It is of especial value in the filling out of defects in plastic surgery about the face, and for replacement purposes in certain cases of delayed skin transplantation. Both sulfanilamide and sulfathiazole, either singly or in combination, and cotton thread sutures were used in the performance of the operations described. A short film was shown illustrating the technique and repair of a large incisional hernia. Six consecutive cases were reported, in each of which primary union with satisfactory results had been secured.

17. **Joseph D. Collins,** Portsmouth, Va.: **A Method of Disposal of the Sac in Operations for Oblique Inguinal Hernia** (abstract).—The inguinal canal having been opened by incising the aponeurosis of the external oblique, the sac is dissected upwards from its bed and freed from its attachments to the cord and cremaster muscle. Any adherent abdominal viscera is released and allowed to drop back into the abdominal cavity. An over-and-over silk suture is passed

around the edge of the open end of the sac, completely encircling it, and this suture is tied loosely with a single knot and laid aside. The index finger is then inserted into the open mouth of the sac and passed through the neck of the sac into the peritoneal cavity, where it is made to impinge firmly against the anterior abdominal wall at a point two inches above the upper border of the internal ring. The fibres of the internal oblique and transversalis muscle over the impinging finger are then separated down to the transversalis fascia for a distance of an inch and a half. This separation is held apart by retractors. With curved Kelly forceps, a puncture is made through the transversalis fascia and peritoneum over the impinging finger, and the point of the blades of the forceps is pushed down through the internal ring, hugging the anterior abdominal wall and in contact with the tip of the finger until it emerges from the mouth of the sac. The suture in the mouth of the sac is drawn tightly around the blades of the Kelly forceps and the knot tied. The Kelly forceps are opened sufficiently to grasp the end of the tied suture and closed. The forceps, grasping the end of the tied sutures, are then withdrawn from the punctured opening in the transversalis fascia and peritoneum, drawing the sac through the opening, thereby inverting it. When the sac is thick and bulky, the opening may have to be enlarged to permit this procedure. The inverted sac is then pulled outward with sufficient tension to eliminate any redundancy in the parietal peritoneum and thus abolish the hernial fossa. The sac is transfixed and ligated, the excess distal to the ligature being excised. The stump of the sac is then sutured to the edge of the opening of the transversalis fascia and peritoneum with a figure-of-eight suture. The opening in the oblique and transversalis muscles is closed with several interrupted sutures. The inguinal canal is then repaired according to the desires of the surgeon.

18. **Edward V. Mastin**, St. Louis, Mo.: **An Operation for the Repair of Inguinal Hernia.**—Surgeons are able to close hernia satisfactorily in the lower angle but many recurrences are due to weakness about the internal inguinal ring. Mastin suggested a new type of closure of the internal ring after the usual suturing of Poupart's ligament to the conjoined tendon and internal oblique muscle. An incision is made in the upper part of the internal oblique muscle just over the internal opening and the cord is brought out through this incision. The muscles on the outside of the cord can be closed so that there is no constriction on the vessels of the cord. The aponeurosis of the external oblique is then closed with the cord being brought out in a similar manner through this fascia. This places the cord on the outside of the external oblique and completely obliterates the middle of the inguinal canal.

Discussion: **C. R. Robins**, Richmond, Va., stressed the importance of exposing the pubic insertion of the rectus abdominal muscles as, in his opinion, most recurrences occur in the lower part of the incision and are due to weakness or absence of the conjoined tendon. **W. F. Rienhoff, Baltimore, Md.**, stated that, contrary to the findings of Mastin, most recurrences at Johns Hopkins Hospital occurred in the lower part of the incision, which he thinks is due to the absence of the conjoined tendon. To cover this defect the fascia from the rectus can be slid over, not turned over, and sutured in place. **Bradley L. Coley**, New York, N. Y., believes the recurrences are due to a number of factors, especially to defects of the tissues in this area. He stressed the importance of the proper suturing of the transversalis muscles. He also called attention to the mistakes which were made by the examining physicians during the first World War and stressed the importance of avoiding them in the present emergency. In his opinion a patient who has large inguinal rings but no hernia should not be subjected to an operation because the majority of these patients will never develop a hernia and the operation is unnecessary and often unsuccessful. **C. C.**

Green, Houston, Texas, stated that the choice of anesthetic is quite important to prevent strain immediately after operation. In his opinion spinal anesthetic is the one of choice. **R. D. Jones, Jr.,** Norfolk, Va., stated that for many years he and Dr. Payne had been using fascia from the external oblique, the advantage being that no separate incision would have to be made to obtain the fascia and its use, in his opinion, lowers the incidence of the recurrence. **A. R. Koontz,** Baltimore, Md., stated the army regulations at the present are different and that hernia is not considered to be present unless the sac can be definitely demonstrated. A large opening of the inguinal canal is not considered to be a contraindication to military service. In his opinion large sheets of ox fascia which have been preserved have all the advantages of either autogenous fascia or cutis grafts and none of the objections. However, he called attention to the fact that the ox fascia is in a preservative and this must be washed out with a saline solution for two hours or more before using. He stated that at one time the preservative used for the ox fascia was inferior, however, this objection has now been overcome and within the last few years there has been no difficulty in this respect.

19. **Warfield M. Firor,** Baltimore, Md.: **Succinyl Sulfathiazole: A New Intestinal Antiseptic.**—One year ago the author reported on his experience in the use of sulfanilylguanidine with particular emphasis on whether it renders surgery on the large bowel safer. Since then the use of this drug has been discontinued because (1) the drug is absorbed and the low blood level is due to its rapid urinary excretion, (2) the drug is erratic in its action, and (3) the drug is toxic. Since that time, E. M. Poth investigated various other sulfonamide drugs and finally settled on succinyl sulfathiazole which has been used in 125 different cases. From their experience (Firor and Poth) they conclude that (1) it alters the physical content of the bowel, rendering it soft and odorless, and (2) it lowers the concentration of certain pathogenic organs such as *B. coli, Flexner, Shiga, and Sonne.* The succinyl radical prevents absorption. The bactericidal action is apparently due to gradual liberation of the sulfathiazole in the bowel. The dosage is 0.25 Gm. per kilogram every 24 hours. The drug is generally given in divided doses every 4 to 6 hours and should be started 3 to 7 days before operation and continued two weeks postoperatively. Of the 125 patients in whom it was used, it was effective in all but six. Of these six, three had increased diarrhea, two had an increased amount of bleeding from an ulcerated carcinoma of the colon and one had postoperative bleeding. In the latter case only 150 c.c. of blood were lost and there was no further complication. They emphasize the fact that it should be understood that this drug is an adjunct and not a substitute for asepsis.

Discussion: **E. M. Poth,** Baltimore, Md., suggested that one of the soluble sulfonamide drugs be used just previous to operation in order to saturate the tissues. Succinyl sulfathiazole is not effective in the typhoid and paratyphoid group but it is very efficient with bacillary dysentery. Twenty cases of bacillary dysentery have been treated and all completely recovered in 24 to 48 hours. Attention was called to the fact that this drug did not effectively sterilize the bowel if there were blind ends or pouches and it was impossible for the drug to reach the bacteria in such conditions. **E. P. Lehman,** Charlottesville, Va., used the drug about three weeks and while his experiences were not enough to warrant any conclusion, his observations were similar to those of the authors and in all cases the blood level remained low. Firor, in closing the discussion, stated that in cases of colostomy or blind pouches, succinyl sulfathiazole could be given both by mouth and as enema irrigations.

20. **Deryl Hart,** Durham, N. C.: **Disinfection of the Air in the Operating Room with Bactericidal Radiant Energy. Correlation of the Intensity of Radiation with Its Bactericidal Effect.**—Statistics show marked lowering of infection

following use of ultraviolet radiation in operating rooms. Several different types of installations of equipment were described. In the author's opinion, contamination of the air is the most important factor causing postoperative infection of clean wounds. He has noted that most infections occur during the months when respiratory infections are most frequent. In his opinion the entire room and the sterile supplies in the room should be irradiated and since proper irradiation has been carried out at Duke University Hospital, the infection rate has been lowered greatly and no fatal infection of clean wounds has occurred where radiation was used.

21. **Ralph G. Carothers,** Cincinnati, Ohio: **Sprained Ankles** (abstract).—The real pathology involved in the so-called sprained ankle is often a fracture or dislocation. Ability to rotate the astragalus after injection with novocain indicated dislocation according to his experience. Carothers discussed work on a cadaver showing that the astragalofibular ligament as well as the calcaneofibular ligament must be severed before the astragalus could be rotated in the mortise.

Discussion: **Clay Murray**, New York, N. Y., stated that recurrent sprain of the ankle is not a sprain and that the astragalofibular ligament is never torn in sprains. Murray further stated that he believed if the tibiofibular ligaments were cut, that there would be enough broadening of the mortise to permit the same rotation as has been shown in the experiments and suggested that this experiment be made. **George E. Bennett,** Baltimore, Md., described his method of using fascia to tie the ligaments in the operation for recurrent sprain. Bennett also suggested that when the foot is plantar flexed, a wider part of the astragalus comes in contact with the malleolus and this may tend to widen the mortise. He suggested that these experiments be done. **Isidore Cohn,** New Orleans, La., regarded most sprains as fractures even if fragments are tiny, and suggested more thorough x-ray studies.

22. **Howard Mahorner**, New Orleans, La.: **Acute Hematogenous Osteomyelitis: A Study of 178 Cases.**—Following use of chemo- and immunotherapy in the past four years, mortality of acute osteomyelitis has been lowered from 24 to 6.6 per cent. Mahorner advocated conservative procedure consisting of hydration with electrolytes and blood transfusions, and chemo- and immunotherapy and minor operations only during early stages, delaying any major surgery until after better preparation of the patient and localization of the suppurative process. He felt strongly that a positive blood culture should be reversed before contemplating surgery. He noted osteoporosis to be the first x-ray evidence but seldom were positive findings seen before the eighth day. Necrosis of bone does not always occur even though the disease is extensive and sequestration frequently fails to appear roentgenologically or clinically.

Discussion: **Mims Gage**, New Orleans, La., pointed out the two types of the disease, i.e., (1) profound systemic reaction with minor local symptoms, and (2) mild systemic reaction with intense local evidence of the disease. Operation in the first group, especially if the blood culture was positive, was followed by a mortality of over 50 per cent. He suggested novocain block of the sympathetics if evidence of vascular spasm existed, and also ligation of the femoral vein in certain cases. **Joseph E. J. King,** New York, N. Y., requested information in regard to the incidence of metastasis following the use of the sulfonamides. **Lenox D. Baker,** Durham, N. C., reviewed the four actions of the staphylococcus organism in regard to the symptomatology of osteomyelitis especially concerning toxemia. He advocated operation as soon as these factors could be properly dealt with and, also, staphylococcus antitoxin given intravenously with which he has had excellent results in acute hematogenous osteomyelitis with bacteremia. In closing, Mahorner stated that he found no reduction in metastases in his last group and also gave the advantages of adequate immobilization in all stages of the disease.

23. **Harry J. Warthen,** Richmond, Va.: **Gas Gangrene: An Analysis of Seventy-One Cases Treated in Civil Practice.**—In a study of all cases treated during the past 10 years an increasing mortality during the past 5 years was discovered. The disease was found to be more prevalent along the Eastern seaboard, and particularly so in Virginia. The recent increase in the mortality was thought to be due to the older age of the patients in this period, and possibly to increased and unjustified reliance upon chemotherapy to cure the disease without adequate surgery. Methods of treatment including chemo- and immunotherapy, x-ray, wide excision, and amputation were discussed and mortality figures given for each group (18.2 to 33.3 per cent).

Discussion: **E. Dunbar Newell,** Chattanooga, Tenn., considered pain at the site of the wound the most important symptom. He felt that early diagnosis could and should be made on clinical evidence alone without waiting for positive smears and x-rays. **Howard M. Clute,** Boston, Mass., had observed gas gangrene to follow abdominal operation in 3 cases with 2 recoveries. He considered early recognition the most important factor in the treatment, and this depends on the surgeon's acumen. **Julian K. Quattlebaum,** Savannah, Ga., described 3 fatal cases of gas gangrene that followed very minor injuries. **Waller O. Bullock,** Lexington, Ky., suggested the use of succinyl sulfathiazole for treatment. Warthen closed the discussion by presenting mortality figures following various methods of therapy. He observed a lower mortality following the average prophylactic dose of perfringens (26 per cent) than with the use of large doses (29 per cent).

24. **John J. Morton,** Rochester, N. Y.: **Inter-Innomino-Abdominal (Hindquarter) Amputation.**—The high mortality accompanying this operation was cited by the author who reported the details of 4 personal cases. Only about 100 cases have been reported in the world literature. Two of the author's cases were done for sarcoma, one for metastasis from a thyroid carcinoma, and the other for chronic osteomyelitis. All of these patients recovered. Pictures and microphotographs of the specimens and x-rays were shown. The details of the operation were also discussed. **Thomas C. Davison,** Atlanta, Ga., reported such an operation performed for carcinoma in a patient aged 70 years, with a seven-year survival.

25. **Frederic W. Bancroft,** New York, N. Y.: **Improved Methods in Extremity Amputations for Diabetic Gangrene** (abstract).—The mortality figures of cases operated on by a sleeve type of thigh amputation were given, and then the improved statistics following a combination of the sleeve type of operation and refrigeration were cited. The changes were stimulated because of the extremely bad-risk patient treated at the City Hospital and the mortality rate which under previous conditions had been prohibitive. In the sleeve operation as described by Fuller, the incision is made through the skin about the level of the tibial tubercle and carried directly through the fascia. The skin and fascia are then clipped together to prevent their separation—an important item to preserve the fascial blood supply. The tendons are transected as they pass through the popliteal space and the blood vessels are grasped and ligated. By scissor dissection the femur is separated from the surrounding bone, hugging the shaft in the dissection backwards. This prevents the opening of the various muscle bundles. The femur is cut through at the junction of the lower and middle third with a Gigli saw in order to prevent large bone chips being disseminated. The patella is then excised from the patellar tendon and the muscles allowed to drop back over the end of the femur. They can then be closed with interrupted layers for the fascia and for the skin without any tension. The technique of the refrigeration method consists of first applying ice at the level upon which a tourniquet is to be applied. This is usually figured to be about two inches above where the femur will be transected. A tourniquet is then

applied and the leg is packed in ice for at least two hours. It usually takes about 50 pounds of ice for a thigh amputation. The patient is transported to the operating room with the leg wrapped in ice and is only removed from the ice when everything is ready to perform the amputation. During the amputation all solutions used in irrigating the wound are to be cold. Thirteen operations were performed under this method, with two deaths, a mortality of 15.4 per cent. Bancroft stated that the skin temperature beneath the ice while refrigeration was being carried out was about 5 to 10° C. In cases with poor circulation the wound should be covered with ice bags for two or three days postoperative, in order to reduce the metabolism in the devitalized extremities. The two deaths that occurred in this series were probably due to emboli.

Discussion: **W. F. Ruggiero**, New York, N. Y., who was associated with the development of this method, stated that the tissues are not actually frozen. He was convinced that the infection so frequently associated with elderly diabetics was definitely inhibited, and as a consequence, lower amputations could be performed. **M. S. Brown**, New York, N. Y., who examined all of the patients, stated that the method allowed sufficient time to get such poor-risk patients in much better condition for major surgery. She observed no reactions following the use of the refrigeration method of anesthesia. **Barney Brooks**, Nashville, Tenn., observed experimental evidence that refrigeration preserved the vitality of tissues, but if associated with infection, the areas of necrosis become larger when normal temperatures return. **Charles B. Venable**, San Antonio, Texas, mentioned the advantages of performing a periarterial sympathectomy several days before amputation.

26. **Leo Brady**, Baltimore, Md.: **The Treatment of Trichomonas Vaginalis Vaginitis with the Lactobacillus.**—The results of another method of treatment of this condition were presented in which the lactobacillus was used. It was noted that this diagnosis was frequently missed because it either was not looked for or the examination was done at an unfavorable time. Stating that the trichomonas is the most frequent cause of leucorrhea and finding that present treatment methods are not always successful, Brady set about to cure the condition by restoring the normal defense mechanism of the vaginal mucous membrane. Skimmed milk was inoculated with the lactobacillus vulgaris, then desiccated and divided into tablets, two of which were inserted into the vagina daily until the vaginal flora was restored to normal. Fifty patients treated in this manner obtained immediate relief, and there have been six recurrences. Samples from each lot of tablets used in this work were examined after being refrigerated for six months. At the end of this time each tablet was found to contain at least 10,000 viable lactobacilli.

27. **W. C. Dixon**, Nashville, Tenn.: **Post Vaginal Hernia** (abstract).—The condition usually but not always followed childbirth and was frequently associated with rectocele and uterine prolapse. It is, however, a definite entity with a peritoneal sac dissecting its way between the rectum and vagina, and was not to be confused with the deep sagging cul-de-sac of prolapse. Some congenital defect in the pelvic floor is probably of etiologic importance. The diagnosis was proved by examination with one finger in the rectum and one in the vagina. The treatment is operative—by abdominal section performing inversion and disposition of the sac and obliteration of the cul-de-sac by the Moschowitz technique. The vaginal approach is preferable unless other pathology requires the abdominal approach. This consists in opening the vaginal plate from the perineum to the cervix, dissecting the sac from the rectum and surrounding tissues, and ligating the neck of the sac with excision of the excess portion. The stump is then anchored behind the cervix and obliteration of the cul-de-sac is accomplished by approximating the uterosacral ligaments. A posterior colporrhaphy completes the operation. The details of a personal case were related.

28. **Edward A. Kitlowski**, Baltimore, Md.: **The Surgical Correction of Mandibular Prognathism.**—The removal of a section of the mandible on both sides for correction of prognathism was advocated and the reports of two cases were cited in which excellent results were obtained. In the first case the teeth were wired together, and in the second, the author used metal caps over the teeth. In this manner the patient was able to take food more quickly and just as satisfactory results were obtained.

29. **J. Barrett Brown**, St. Louis, Mo.: **Massive Repairs with Thick Split Skin Grafts.**—As far as could be told there is no relation between the blood group and the taking of skin grafts for homo-skin grafts and to the author's knowledge none of the grafts are ever permanent, but in numerous cases homo-skin grafts used as dressing have been lifesaving procedures in cases of extensive burns. Studies have been made with grouping donors into the M and N groups without changing this observation. The protection of and the healing of donor sites of skin grafts was discussed and the complete surface healing in six days by squamous epithelium from the follicles deep in the derma was shown microscopically.

30. **Edward H. Richardson**, Baltimore, Md.: **Diverticulum of the Ureter.**—The literature on diverticulum of the ureter was reviewed briefly. The first case was reported in 1911 and the first case demonstrated by intravenous pyelography was in 1936. A total of 32 clinical cases have been reported previously and in them, eight contained stones. As far as could be told from the cases reported, there was no characteristic syndrome. Richardson reported a case which is to his knowledge the largest one recorded to date. The patient was a female, aged 39, who complained of enlargement of the abdomen. There were absolutely no symptoms referable to the urinary system. At operation a large mass was found in the abdomen and from it was aspirated 3,500 c.c. of urine, and then the sac was removed and the ureter reconstructed. These diverticula may be either congenital or acquired.

31. **Addison G. Brenizer**, Charlotte, N. C.: **Ureteral Transplantation** (abstract).—A series of cases of ureteral transplantation and cystectomy done by the better known treatment methods was cited and compared with a series performed by the author's method. The efficacy of this procedure was proved by history, portrayal of the cases, and urograms made eight years after operation. A case was described in a male patient where the vasa deferentia and seminal vesicles had been preserved, a rim of bladder united over the prostatic urethra and a repair of the epispadias performed. Ejaculation and viable spermatozoa were maintained in a boy, 17 years of age, for eight years following operation. Another case cited was that of a girl 18 years of age, where the ureters and pelves were shown to have returned to approximately normal dimension in the course of eight years. A comparison of the author's method with the refinement of the original Coffey-Mayo procedure as done by Walter and Cabot, Ladd and Lanman, and Lower was outlined. It was pointed out that both operative methods had one very important point in common, i.e., they eventually turned the whole calibre of the ureter into the rectum and cut off the entire flow of urine to the bladder. The author's method required but one abdominal operation, whereas the Coffey-Mayo procedure required two. In his technique, the rectal mucosa was never opened nor transfixed with a suture and the abdomen never exposed to an infection from the bowel. The ureters were not cut immediately, but only after nine days, when they were embedded in the intestine after all hemorrhage, edema, and lameness had subsided. Brenizer further pointed out that his adaption of the incisions into the rectum loosely and the fact that the ureters were barely raised from their bed, did not disturb to any extent the blood supply and nerve supply to the ureter and allowed the ureter

to rotate in the intestinal channel. The intestine was able to better adapt itself to the ureter thus keeping it straight in its course in the intestine and causing no obstruction to it. His technique consisted of implanting simultaneously a segment of both intact ureters into the intestine within the mucosa. A long hairpin wire, sharpened on the ends, was made to straddle the ureter and to pierce the mucosa passing into a whistle-tip catheter which had been placed in the rectum. The wire was passed through the catheter to emerge at the anus leaving a small loop surrounding the ureter. Eight days later the ureter was enveloped by the wire loop and implanted into the intestine, and then severed by the application of an electrocutting current to the wire ends emerging through the catheter at the anus. The assurance that each ureter was severed and totally turned into the rectum was easily ascertained by the absence of flow of urine into the bladder and the flow of urine into the rectum, proved by urograms.

32. **Lawrence R. Wharton**, Baltimore, Md.: **Simultaneous Obstruction of Both Ureters with Uremia** (abstract).—The author presents a series of 7 cases of simultaneous obstruction of both ureters with uremia. The causes were stricture, 2 cases; stone, 2 cases; carcinoma of bladder, 1 case; back pressure from overdistended bladder, 1 case; bilateral ligation of ureters, 1 case. The commonest causes are stricture and stone, both of which are often associated with infection. In all of these cases there had been urinary disease for years before acute obstruction with uremia developed. But in all these cases of stricture and stone, the situation had been neglected by the patient because it was causing no pain, or was treated observantly by the physician. These cases show that serious urinary disease may be present without causing any pain. Typical ureteral colic may be absent in ureteral obstruction. Urinary infection, incomplete obstruction and stone should not be neglected or allowed to progress to complete renal destruction. There was one fatality in this series, due to carcinoma of the bladder. The author discussed methods of treatment and problems that arise during treatment of various types of ureteral obstruction.

Discussion: **W. H. Parsons**, Vicksburg, Miss., stated that he still used the multiple-stage operation and in his hands it is better and has a much lower mortality and morbidity. **H. L. Foss**, Danville, Pa., made a plea for a return to the simple forms of transplantation, the use of nonabsorbable sutures, and the use of sulfonamide drugs. He reported 5 cases seen in the past few weeks on which he had obtained excellent results.

33. **Ambrose H. Storck**, New Orleans, La.: **The Use of Estrogenic Substances in the Preoperative and Postoperative Treatment of Hyperthyroidism: Further Observations** (abstract).—Various possible mechanisms which might account for the experimentally observed lowering of basal metabolism which follows the administration of estrogenic substances and which might account for the beneficial effects following the administration of estrogenic substances to patients with hyperthyroidism were discussed. The group included the suggestion by Sherwood, and later by Grumbrecht and Loesser, that estrogen may inhibit the production of anterior pituitary thyrotropic hormone; the possibility of a direct hormone antagonism in the tissues, as later suggested by Sherwood in view of his demonstration that estrogen therapy causes lowering of basal even in thyroidectomized animals; and inhibitions of production of various anterior pituitary calorigenic hormones. Observations made in 11 cases with hyperthyroidism in which the usual supplementary treatment including bed rest, sedation, and the administration of iodine, calcium, vitamins and a high caloric, high protein diet was supplemented with estrogen therapy, using either theelin in oil or diethylstilbestrol given by mouth, were summarized and compared with a series of control cases who received the same basic treatment but to whom estrogenic substances were not given. Even in cases refractory to the usual preoperative

treatment, an additional lowering of basal metabolic rate followed estrogen therapy. An average preoperative lowering of pulse rate equal to that which occurred in the control group was observed in the estrogen treated cases, even though more of the cases which received estrogen therapy were iodine fast at the time of admission. The average peak pulse rate on the first postoperative day in the cases which received estrogen therapy was lower than was the average peak pulse rate on the same day in the control group. Patients who received estrogens consistently looked and felt better than did the control group, this difference being most pronounced during the immediate postoperative period. Although no definite conclusions can so far be drawn concerning a relation between dosage and effect, comparison of the presently reported observations with those following smaller average doses suggests that small doses of estrogenic substances are equally, if not more effective, than are large doses. Reference was made to the possibility of refractoriness to estrogen therapy following repeated doses. Estrogen therapy is probably most effective when administered for from four to seven days preceding operation when subtotal thyroidectomy is done in one stage. When multiple stage thyroidectomy is performed, it seems advisable to continue estrogen therapy for several days following the first stage, and if there is a lapse of more than a week between operations, to reinstitute estrogen therapy preceding the second stage. It was believed that the employment of this form of collateral therapy is valuable in severe hyperthyroidism, particularly when multiple stage procedures are necessary, and in iodine fast cases. No conclusions can yet be drawn concerning the relative values of theelin and diethylstilbestrol as estrogenic substances suitable for use in hyperthyroidism.

34. **Edward T. Newell**, Chattanooga, Tenn.: **The Treatment of Cancer of the Breast Using Cautery Excision, Implantation of Radium, Preoperative and Postoperative, Radiation** (abstract).—The author reviewed his experiences and divided the cases into (1) inoperable, (2) operable confined within its limits, and (3) operable with metastases. By reason of the fact that the Halsted operation or the Willy Meyer operation produced only 25 per cent of cures where axillary involvement was present, Newell was of the opinion for many years that something in addition to the perfect radical operation should be done to increase this low 5-year arrest and it was for that reason that he instituted the use of radium in the axilla and postoperative x-ray treatment. He believes that this has increased the number of 5-year cures (arrest) at least 10 per cent with the addition of the cautery resection and postoperative irradiation. In rare instances preoperative irradiation was used. In comparison, twice as many patients lived three or more years without axillary or other metastases as did those with such extension (81 vs. 40.6 per cent). In a series of 60 personal cases he found that Grade 3 and 4 predominated (70 per cent), and there was an operative mortality of 1 per cent. The details of the author's method of using cautery excision and radium implantation were shown by a motion picture. Average duration of the tumor was 17.5 months, and 68.6 per cent had axillary metastases. He used preoperative radiation only in the well-advanced cases and followed in 4 to 5 days with the surgical attack.

Discussion: **Hugh A. Gamble**, Greenville, Miss., used the cautery method of excision. He also advocated transplantation of the latissimus dorsi over the denuded chest and axilla. No swelling in the area followed this method. **Deryl Hart**, Durham, N. C., raised the question of increased swelling of the area following implantation of radium and cautery excision. He described the methods used at Duke Hospital stressing the advantage of a light plaster cast dressing to promote primary wound healing. **Bradley L. Coley**, New York, N. Y., talked about the disadvantages of preoperative x-ray treatment mentioning particularly the skin changes and scar formation. He stated that postoperative radia-

tion was used at Memorial Hospital and described the operative technique used there. In his opinion inflammatory carcinoma was inoperable. **John E. Cannaday,** Charleston, W. Va., pointed out the value of getting patients out of bed early, and also advocated the use of cotton suture material.

35. **D. Henry Poer,** Atlanta, Ga.: **Effect of Removal of Malignant Thymic Tumor in a Case of Myasthenia Gravis** (abstract).—Statistical evidence was given to show the presence of thymic abnormalities in over 50 per cent of cases of myasthenia gravis as proved by autopsy or operation. The increase in this percentage in recent years indicates the probability of a consistent association of these conditions. The extraordinarily few operations that have been performed upon patients with myasthenia gravis have usually been done for removal of benign thymic tumors, and the results were not particularly encouraging. Recently Blalock and his associates have removed a thymic cyst from a patient, which was followed by dramatic improvement, and they also have explored the thymic area of six myasthenic patients removing remnants from all with encouraging beneficial results. In the literature only four reports of malignant thymic tumor could be found that have been discovered at autopsy in cases of myasthenia gravis. The author adds a report of a carcinoma of the thymus which was successfully removed from a 52-year-old male who had suffered with a severe form of myasthenia gravis for 2 years. This was followed by marked clinical improvement and no evidence of recurrence up to the present time.

Discussion: **Joseph E. J. King,** New York, N. Y., mentioned the 2 cases operated upon by Campbell and asked if they had been included in the cases studied. **Edward D. Churchill,** Boston, Mass., pointed out the difficulty of establishing a definite diagnosis of myasthenia gravis. He gave his experience in dealing with four patients with mediastinal tumors who at one time or another presented symptoms suggestive of myasthenia gravis. He considered the response to prostigmin to be the most accurate diagnostic test (described by Viets). **Barney Brooks,** Nashville, Tenn., stated that he had recently examined Blalock's first patient (thymic cyst removed in 1936) and found no symptoms of myasthenia gravis.

36. **Daniel L. Borden,** Washington, D. C.: **Personal Observations During the Recent A. M. A. Trial.** The details and many personal incidents of the recent trial of the American Medical Association were described. This was discussed by **John H. Lyons** and **Harry H. Kerr,** Washington, D. C., who related the involvement of the local Medical Society in this important trial.

37. **Amos R. Koontz,** Baltimore, Md.: **Are Selective Service Rejections an Index of the State of Our National Health?**—It was pointed out that many misstatements concerning this question are receiving popular attention at the present time. The statement that 40 per cent of our draftees are undernourished was found to be grossly untrue. Koontz stated that the average height is the same, the average weight is better, and the number of rejections for tuberculosis is less than in World War I. He found venereal diseases decreasing in the Army in spite of recent statements to the contrary, and that bad teeth were the principal cause for rejection. He also noted a much lower morbidity and mortality rate than in World War I and that the general health and morale were good.

Discussion: **Harvey B. Stone,** Baltimore, Md., emphasized the bad effects on the public morale of the absurd misstatements that have received so much publicity. He had found public health in relatively good condition.

Book Reviews

Surgical Diseases of the Spinal Cord Membranes and Its Roots. By Charles A. Elsberg. Pp. 598, with 249 illustrations. New York City, 1941, Paul B. Hoeber, Inc. $14.00.

This is a new and revised edition of the author's previous books on the spinal cord, *Diseases of the Spinal Cord,* 1916, and *Tumors of the Spinal Cord,* 1925. Chapter III, The Roentgen Ray Diagnosis of the Spinal Cord Meninges and Vertebrae, was written by Cornelius G. Dyke and Chapter VIII on the pathology of cord tumors was written by Abner Wolf.

It is an excellent monograph reflecting the author's extensive experience, his multiple contributions on the spinal cord which have been published in the periodical literature since 1912, and a thorough knowledge of the literature. Positive statements are made concerning the author's opinion and practice even on the most controversial subjects.

The illustrations, 249 in number, are well chosen and well reproduced. Chapter subdivisions in large type and the free use of italicized paragraph headings for lesser subdivisions make the book more readable. At the end of the book, references are listed alphabetically and there is also a list of authors with page references to each. However, not all references are listed and the page references to authors listed are also incomplete. These omissions are noted especially in Chapter VIII.

In general the style is clear and the diction good. But on page 185 it is stated that "the primary lesion was metastatic." One who has recently learned anatomy would ponder on the location referred to as follows "on the lower part of the cheek below the area of distribution of the inframaxillary part of the trigeminus." (Page 390.)

Many surgeons would disagree with the statement that "the region from which a foreign body has been removed should be gently swabbed with weak iodine so as to forestall a possible secondary infection."

This book is favorably recommended to everyone who examines or treats surgical diseases of the spinal cord.

Books Received

The receipt of books is acknowledged in this section and this statement must be regarded as sufficient acknowledgment of the courtesy of the senders. Selections will be made for more extensive review dictated by the interests of our readers and as space permits.

OPERATIVE SURGERY: ABDOMINAL SURGERY. By F. W. Bancroft, A.B., M.D., F.A.C.S., Associate Clinical Professor of Surgery, Columbia University, New York City. Cloth. Pp. 1102, with 250 illustrations. New York, 1941, D. Appleton-Century Co., Inc.

SULFANILAMIDE AND RELATED COMPOUNDS IN GENERAL PRACTICE. By Wesley W. Spink, M.D., Associate Professor of Medicine, University of Minnesota. Cloth. Price $3.00. Pp. 256. Chicago, 1941, The Year Book Publishers, Inc.

TEXTBOOK OF GENERAL SURGERY. By Warren H. Cole, M.D., F.A.C.S.; and Robert Elman, M.D., Department of Surgery, University of Illinois, Chicago. Cloth. Price $8.00. Pp. 1067, with 558 illustrations. New York, 1941, D. Appleton-Century Co., Inc.

WOUNDS AND FRACTURES: A CLINICAL GUIDE TO CIVIL AND MILITARY PRACTICE. By H. Winnett Orr, M.D., F.A.C.S., Nebraska Orthopedic Hospital. Cloth. Price $5.00. Pp. 227, with 137 illustrations. Springfield, Ill., 1941, Charles C Thomas, Publisher.

DISEASES OF THE THYROID GLAND. By Arthur E. Hertzler, M.D. Cloth. Price $8.50. Pp. 670, with 495 illustrations. New York, 1941, Paul B. Hoeber, Inc.

A MANUAL OF THE TREATMENT OF FRACTURES. By John A. Caldwell, M.D., Professor of Clinical Surgery, University of Cincinnati College of Medicine. Cloth. Price $3.50. Pp. 150, with 76 illustrations. Springfield, Ill., 1941. Charles C Thomas, Publisher.

TREATMENT OF THE PATIENT PAST FIFTY. By Ernst P. Boas, M.D., Associate Physician, Mount Sinai Hospital, New York City. Cloth. Price $4.00. Pp. 324, with 19 illustrations. Chicago, 1941, The Year Book Publishers, Inc.

SURGERY OF THE HEART. By E. S. J. King, M.D., M.S., D.Sc., F.R.C.S. (Eng.), F.R.A.C.S., Major A.A.M.C., University of Melbourne, Australia. Cloth. Price $13.50. Pp. 728, with 268 illustrations. Baltimore, 1941, Williams and Wilkins Co.

EPILEPSY AND CEREBRAL LOCALIZATION. By Wilder Penfield, Litt.B., M.D., D.Sc., McGill University, Montreal; and Theodore C. Erickson, M.A., M.Sc., M.D., McGill University, Montreal. Cloth. Price $8.00. Pp. 623, with 163 illustrations. Springfield, Ill., 1941, Charles C Thomas, Publisher.

SURGICAL CLINICS OF NORTH AMERICA. By nineteen contributors. Cloth. Pp. 1521, with 348 illustrations. Philadelphia, 1941, W. B. Saunders Co.

SURGICAL PRACTICE OF THE LAHEY CLINIC. By Frank H. Lahey, M.D., and others. Cloth. Pp. 897, with 376 illustrations. Philadelphia, 1941, W. B. Saunders Co.

SURGICAL CLINICS OF NORTH AMERICA. By many contributors. Cloth. Pp. 333, with 389 illustrations. Philadelphia, 1941, W. B. Saunders Co.

SURGERY OF MODERN WARFARE. By Hamilton Bailey, F.R.C.S., Royal Northern Hospital, London. Cloth. Price $10.00. Pp. 899, with 828 illustrations. Baltimore, 1941, Williams and Wilkins Co.

ENDOTRACHEAL ANESTHESIA. By Noel A. Gillespie, M.D., State of Wisconsin General Hospital, Madison, Wisconsin. Price $4.00. Pp. 187, with 44 illustrations. University of Wisconsin, 1941, University of Wisconsin Press.

PSYCHOSURGERY: INTELLIGENCE, EMOTION AND SOCIAL BEHAVIOUR FOLLOWING PREFRONTAL LOBOTOMY FOR MENTAL DISORDERS. By Walter Freeman, M.D., Ph.D., F.A.C.P.; James W. Watts, B.S., M.D., F.A.C.S., George Washington University, Washington, D. C. Cloth. Price $6.00. Pp. 337, with 81 illustrations. Springfield, Ill., 1942, Charles C Thomas, Publisher.

A TEXT BOOK OF NEURO-ANATOMY, ed. 3. By Albert Kuntz, Ph.D., M.D., Professor of Micro-Anatomy, St. Louis University School of Medicine. Cloth. Price $6.00. Pp. 518, with 307 illustrations. Philadelphia, 1942, Lea and Febiger.

CLINICAL ROENTGENOLOGY OF PREGNANCY. By William Snow, M.D., Director of Radiology, Bronx Hospital. Cloth. Price $4.50. Pp. 178, with 117 illustrations. Springfield, Ill., 1942. Charles C Thomas, Publisher.

HELP YOUR DOCTOR HELP YOU (SERIES): (1) Colitis (2) Food Allergy (3) Gallstones and Diseases of the Gallbladder (4) Gastric or Duodenal Ulcer (5) Migraine. Editorial Board, Dr. Walter C. Alvarez, Editor-in-Chief. New York, 1941, Harper & Brothers.